POWER PLANT ENGINEERING

Established Over 35 Years

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Contents of this Issue

	Page
The Power Behind New York	584
Pumped Storage for Regeneration. By L. F. Harza	597
District Heating in Pittsburgh	601
Natural Gas Pipe Line, Texas to Chicago	601
Significance of Alkalinity in Embrittlement Studies—I. By Max Hecht and D. S. McKinney	602
Modern Turbine Lubrication Practice. By W. F. Fitzgerald	604
Steam Piping for 1000 Deg. By J. H. Walker	606
Safety in Pulverized Fuel Systems	609
Contract Let for Design of New Steam Heating Plant at Washington	609
What Method Should Be Used to Give a Fair Comparison of Steam Station Performance? By C. C. Baltzly	610
Electricity—What It Is and How It Acts. By A. W. Kramer	614
Photographic Flame Studies in the Gasoline Engine. By Lloyd Withrow and T. A. Boyd	617
Brine Race Systems for Freezing Ice. By Terry Mitchell	618
Replacement of Obsolete Motor Coils. By A. C. Roe	619
Power Conveying vs. Muscle	621
Inspection Aids Equipment Maintenance. By August Heckman	622
Standard Gas & Electric Co. Shows Customer Increase	623
Letters Direct from the Plant: Combustible Storage Rooms. Pulverized Coal Plant for Ships. Revolving Derrick Electrically Lighted. Cylinder Drain Botched. Quick-Acting, Wide-Opening Clamp. Repairing Celluloid Instruments. Quick Freezing for Pipe Repairs	624
Questions and Answers: Cleaning Injectors with Acid. Boiler Calculations. Strong Aqua Concentrations	627
Editorial Comment: A Standard Set for Utility Management. Contract Ice. Inside Information. Food Preservation	628
Straightline Sewage Screen	630
Shadow Wall Burner, Air-Cooled Wall and Coal Distributor	630
Bleeder Line Protecting Valves	631
Inverted Bucket Steam Trap	631
Hydroseal Pump	632
Spiral and Loose Metallic Packing	632
High Capacity Safety Valves	633
Death of Dr. Albert A. Michelson	633
Dr. Samuel W. Parr Dies After Long Illness	633
Annual Oil and Gas Power Meeting at Madison, Wis.	634
News Notes	634
Books and Catalogs	635
Power Plant Construction News	636

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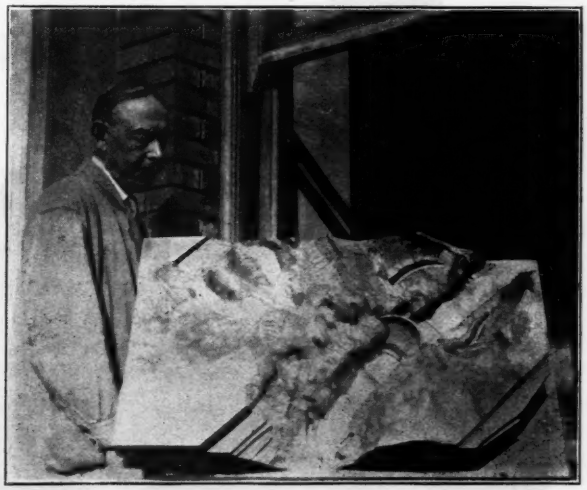


Care and Feeding of Ideas

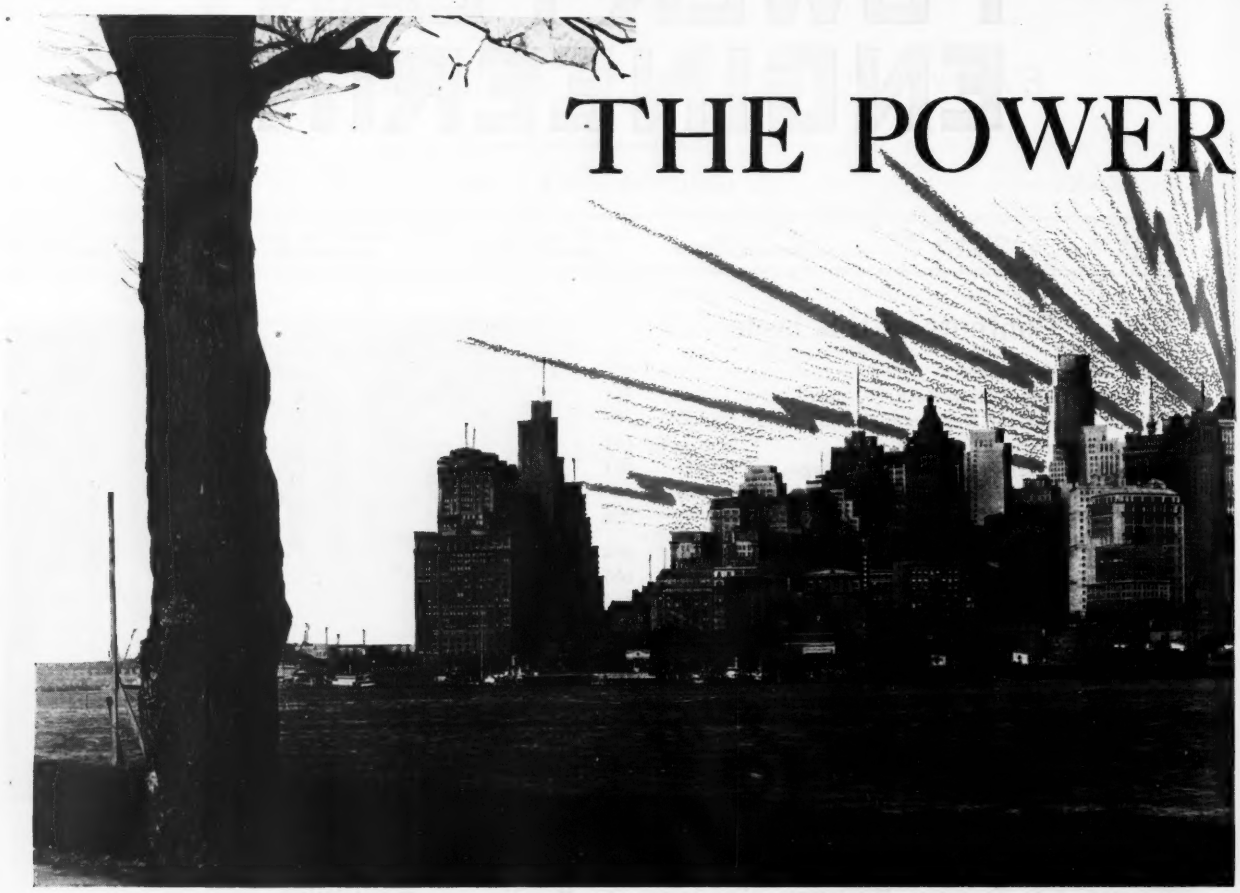
HYDRAULIC ENGINEERS know many things about the care and feeding of ideas and especially about the pre-natal care that is necessary before ideas can be born, to make sure that they will come at just the right time, healthy and ready to begin useful lives.

To stimulate the growth of existing ideas and to provide the proper conditions in which new ones can be born, hydraulic engineers often resort to the apparently juvenile pastime of playing with blocks. These are not the ordinary building blocks of the nursery; they consist of models of dams, intakes, draft tubes and other water passages or sometimes of a complete project, such as that shown above, a scale model of Hoover Dam and surrounding territory.

This was constructed by McDonald & Kahn so that a study could be made to determine the best location for construction equipment. The model shows the cofferdams on either side of the main dam, which can be removed from the model. Diversion and spillway tunnels are also shown.

Models on a larger scale than this have often been used to predict conditions in the full-sized structure and some of the ideas born in such studies have produced great savings in the cost of hydroelectric projects.

One of the most interesting ideas ever born to hydroelectric engineers is that of the pumped storage hydroelectric plant. This infant is growing strong and healthy and before long may develop into quite a lusty youngster. Detailed data on its care and feeding are presented on page 597 of this issue by L. F. Harza.



THE POWER

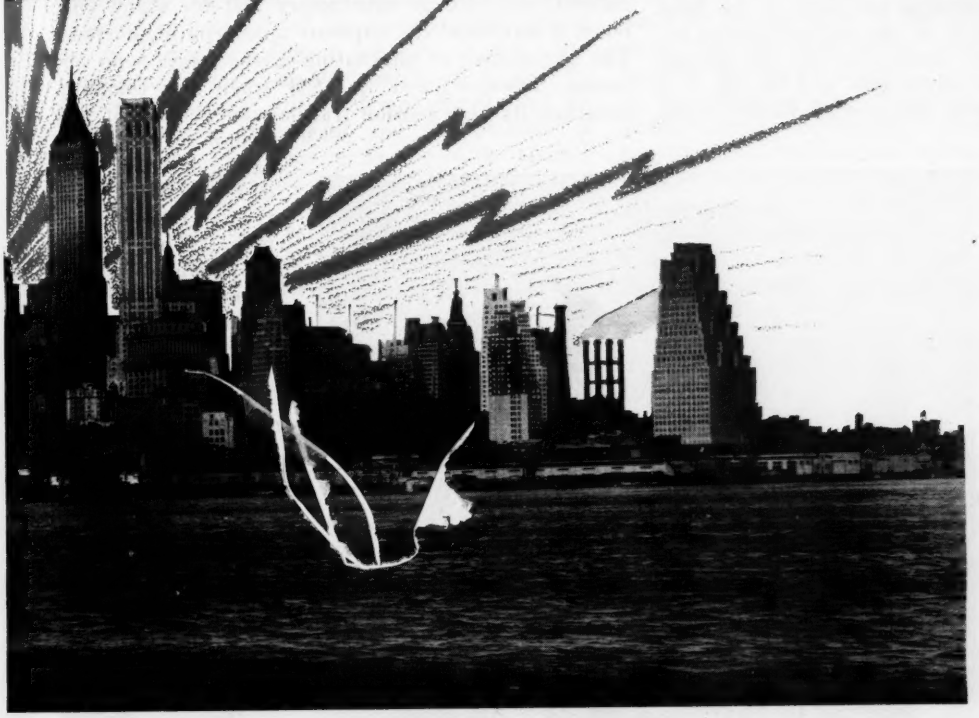
The Technical and The New York

NEW YORK CITY represents one of the greatest concentrations of population in the world. In the area occupied by the city proper there dwell over six million of perhaps the most enterprising human beings on earth. These people range through all sections of our social structure and represent all stages in the development of our civilization; they are of all nationalities and of all human impulses and desires. In this area, comprised of Manhattan Island, the southern part of Long Island and a small area to the north of Manhattan, these six million people live and die, love and hate, work and play and satisfy their individual desires in accordance with their respective notions and philosophies. On the whole, they are a self centered people, taking much for granted and little disposed to thinking about how their various wants and demands are satisfied. Their clothing they make, not individually but collectively for the nation. Their food they eat but little realize where it comes from or how it is brought to them. Their transportation is at once the most highly developed and in a certain sense the most demoralized in the world, but it is quite obvious—it needs no explanation. Of their electricity supply, of the light and power which they use in enormous quantities, these six million know very little. If they ever give thought to it, it is only in the most superficial connection—they accept it as a matter of course; take it for granted. Electricity? Certainly, the power company makes it—we press the button. Why worry?

But let that electricity supply be interrupted for ever so short an interval of time; let the lamps be darkened for the most fleeting instant and what a howl of anguish ascends to the heavens! "Our power is off—we have no light—our elevators won't run—our factory is shut down—it is costing us money"! A thousand telephone calls, ten thousand protests in the course of a minute. Then, and only then, by the absence of it does the population become electricity conscious and then also all the explanations and excuses in the world will not suffice—the power company is to blame—"the service is awful".

Supplying electricity to any community is not an easy task but when that community is New York City, the task becomes one of almost superhuman difficulty and complexity and calls for the utmost in engineering knowledge and executive resources. It requires the careful coördination of many factors and the intelligent cooperation of many highly trained individuals—it requires engineering skill, executive ability, diplomacy, tact and vision. It requires careful planning and eternal vigilance.

BEHIND NEW YORK



THE SKYLINE OF MANHATTAN FROM GOVERNORS ISLAND

Photo by Underwood and Underwood

Economic Aspects of Edison System

For New York more than any other city in the world, owes it existence to electricity; without electric power, modern New York could not be. Underneath the myriad manifestations of human activity, the excitement and glamour, the force of human expression, there is an unseen power which drives everything on. Underneath the towering structures and canyon-like streets there is a vast nervous system of pipes and tunnels, wires and cables, the arteries and veins, so to speak, which gives the city life. This system provides it with light and motion, waters it, and makes it articulate. And the driving force is *electric power*.

Hurtling a thousand subway trains through colossal pipe lines, this power fairly pumps millions of people a day in and out of the city. On Broadway it illuminates ten thousand giddy signs and as many theatres and restaurants—here darkness never falls. More eternal than mythical temple lamps, the lights of New York never go out.

The electric strength of New York is amazing. Someone with a penchant for statistics has figured that its elevators alone carry 10,500,000 people 78,500 mi. a day! Trains, cars, tunnels, pumps, signals, alarms, elevators, illumination, telephones, telegraphs, bells, buzzers, broilers, ovens—nearly 65,000 uses, it is said, are the applications of electricity in New York.

What if the current fails? Panic, paralysis, chaos; millions marooned in skyscrapers or trapped in subways, all dark. Imagine walking down from the 86th floor of the Empire State Building! Merely to think of this is to show the utter dependence of New York on power and light.

From this, and from even the most elementary considerations of geographical conditions as well as from the sociological and economic importance of New York City, it is obvious that the system which supplies this city with electric power must be highly organized. This function falls to the lot of the New York Edison system which it is our privilege to describe in this and succeeding articles.

Like any other structure of its kind, the New York Edison system is the product of an evolutionary process—its characteristics, therefore, have some relation to the manner of its growth. The development of the New York Edison system, however, is perhaps more interesting than that of other similar systems, for it had its origin in the Pearl Street station, the first steam central station in the world. The development of the New York Edison system, therefore, is the development of the central station industry itself.

However interesting it would be, it is not the purpose of this article to describe the evolution of the

New York Edison system, but in order that we may understand better the structure of the system as it exists today as well as its workings, it is desirable to refer briefly to certain factors in its early development.

Aspects of the System's Growth

Pearl Street station, formally opened on September 4, 1882, marked the beginning not only of the New York Edison but also that of the central station industry itself. Since that memorable day the process of development has been continuous and though it is a far cry from the Jumbo dynamos of Edison's first venture in commercial incandescent lighting, to the 160,000-kw. generators at Hell Gate and East River today, the spirit which led to the building of these modern giants is the same as that which carried Pearl Street through its infancy. A study of the system's growth reveals an ideal and an adherence to purpose steadily pursued through a half century of progress.

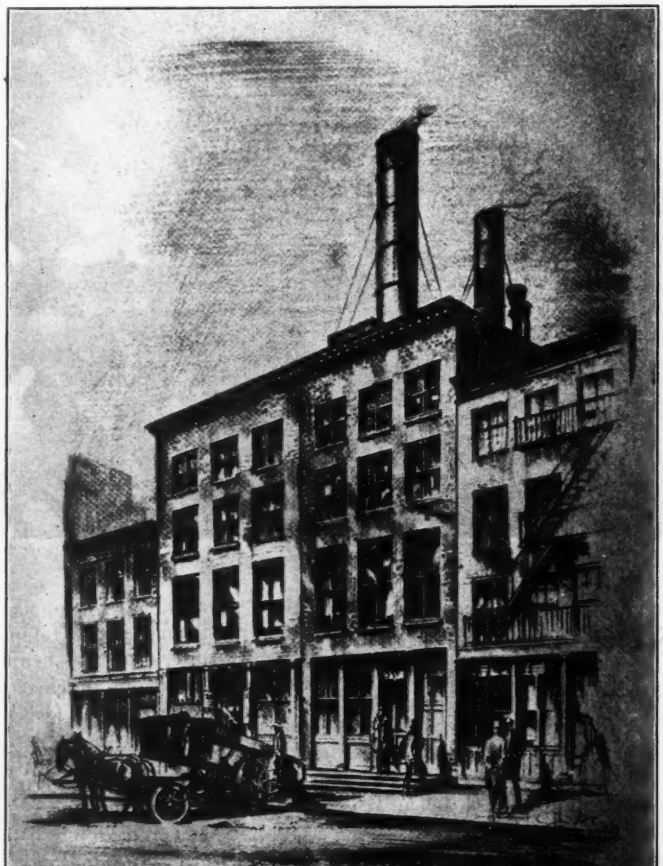


FIG. 1. PEARL STREET STATION, THE FIRST CENTRAL STATION IN THE WORLD

Pearl Street Station on the New York Edison system was supplemented by the 26th and 39th Street Stations in 1888, the 53rd Street Station in 1893 and the 12th Street Station in 1895, all long since discontinued as generating plants and now used as converter substations. In 1891 Duane St. Station was built and in 1901 Waterside No. 1 came into existence. This was followed in 1906 by Waterside No. 2 and by the Sherman Creek plant of the United Co. in 1913. In the meantime, 66th St. and Gold St. Stations in Brooklyn were built by the Brooklyn Edison Co. At that time these were all separate companies. Waterside station at the time of its opening represented the last word in power generating practice, and for many years was looked upon as one of the great stations of the world. Today it is still operating and while not as efficient as the more modern stations, it still is an important factor in the system.

At the time the central station industry was born and for many years after, direct-current was the only form of electric current known or at least thought useful; indeed, it was not until 1893 that George Westinghouse first successfully demonstrated the practicability of alternating current. For this reason, the early growth of the New York Edison Co. was entirely along direct-current lines, even after the use of alternating-current had been shown practicable. Direct-current was entirely satisfactory and for many purposes it was decidedly superior to alternating-current. The advantages of alternating-current were soon apparent, however, and in 1898 when the company launched its high tension transmission scheme, it was recognized that alternating-current was more suitable for transmission purposes. Thus, when the splendid Waterside station was built in 1902, it was an alternating-current station feeding 6600-v. 25-cycle alternating-current to direct-current substations. In 1896 an experimental station of this nature had been installed at 72nd St. and 5th Ave., transmitting 2400-v. current. Thus, while alternating-current was used for transmission, the ultimate service to the consumer was still direct-current. For such transmission to substations, 25-cycle current was more economical than 60-cycle current, hence the adoption of this frequency.

Later when the advantages of alternating-current service to the consumer became more apparent, 60-cycle generators were installed supplying 60-cycle current directly to the customers but these were mostly new services in the more outlying parts of the system. The downtown areas of Manhattan and Brooklyn continued to grow as direct-current areas.

Thus, two systems of distribution developed, one a 25-cycle system supplying direct-current substations, and the other a 60-cycle system furnishing alternating-current to the consumer through transformer substations. These two systems underwent simultaneous growth, as the city increased in size and population and although the policy in regard to further expansion of the direct-current system has now been changed, the two frequencies still characterize the system today. This

accounts for the fact that in many of the generating stations serving the system both 25- and 60-cycle generators are installed.

In the early years of the century this method of operation was quite satisfactory but when due to the steadily increasing concentration of population the downtown load increased enormously, the continued development and growth of the direct-current system became an increasingly difficult problem. It was a distinct handicap. The enormous amount of copper required for low voltage, direct-current distribution involved considerable investment and the problem of finding space for these large conductors in the already congested streets of the city became more acute each year.

Until 1927 there were four separate companies serving the New York area, the New York Edison and The United Electric Light and Power Co. in Manhattan and the Bronx, the Brooklyn Edison Co. in Brooklyn and the N. Y. & Queens E L. & P. Co. in Queens. Until this time each of the companies met their own problems regarding direct-current as best they could but there was no general action regarding curtailment until the four companies became associated under one executive management in 1928 with M. S. Sloan as president. Mr. Sloan had been president of the Brooklyn Edison and was fully familiar with the problems of the system.

Since that time, the policy regarding the recession of the direct-current load and the 25-cycle system has been very rigid. The present policy calls for a gradual recession of the 25-cycle system by adding only new 60-cycle load and changing over from direct-current to alternating-current which results in a further diminution of the 25-cycle load. The 60-cycle load is being added to rapidly—to supply the new 8th Avenue Subway alone some 210,000 kw. additional of 60-cycle capacity will be needed by 1940. On the Brooklyn Edison system, the change from alternating to direct-current has gone far; to such an extent, in fact, as to effect the retirement of some of the substations. This is due to the fact that even before the consolidation in 1928, it had been the policy of the Brooklyn Edison to curtail the growth of the direct-current system. On the New York side, this change has not proceeded as far but now it is being carried out there as well. For the time being, at least, it has halted the further 25-cycle growth of East River Station.

At the time that these policies of conversion were inaugurated, it was recognized that until the transition from the 25- to 60-cycles was complete, the entire system could be strengthened by the introduction of suitable converting equipment which would render some of the installed generating capacity of one frequency available on the system of other frequency. To this effect, frequency changer equipment totaling some 190,000 kw. has been installed in the various generating stations through which energy from the 60-cycle system can be delivered to the 25-cycle system and vice versa. These frequency changers have functioned with remarkable success. There are five of them altogether, three of 40,000 kw. capacity and two of 35,000 kw.

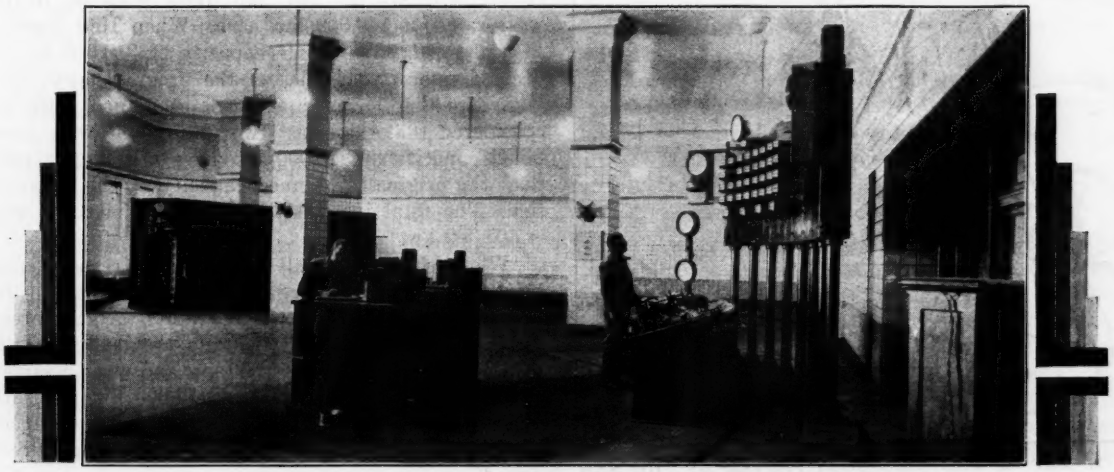


FIG. 2. IN THE MAIN CONTROL ROOM AT EAST RIVER STATION

With this arrangement, together with the tie feeders between the various generating stations, the entire system functions as a definite unit. The use of the frequency changers not only limits the investment in generating equipment necessary but also insures greater reliability and freedom from interruption.

Hand in hand with this policy of receding the 25-cycle and direct-current systems, is the policy in regard to the development of the a.c. network. The general idea is to eliminate the use of substations. Instead, the plan in force is the feeding of blocks of power from the generating stations directly to the a.c. network, without the use of a substation. No more substations are being built.

In Manhattan at least, it is becoming customary to run high potential a.-c. cables (13,200-v.) to the upper floors of extremely tall office buildings, stepping down to lower voltages at those points.

With this somewhat disconnected historical introduction, we are now able to consider the structure of the present system.

The Present System

The territory served by the New York Edison system, shown in Fig. 3, covers approximately 550 sq. mi.

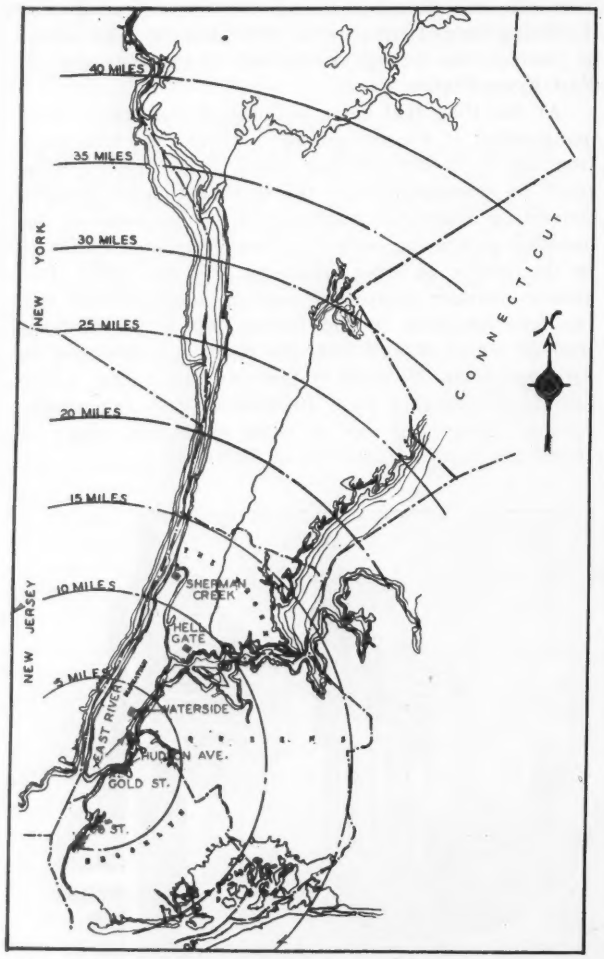


FIG. 3. MAP OF THE TERRITORY SERVED BY THE NEW YORK EDISON SYSTEM, SHOWING GENERATING STATIONS

and embraces the four Boroughs of Manhattan, the Bronx, Brooklyn and Queens and part of the county of Westchester.

At present the system is composed of five affiliated companies each operating as separate corporate entities but having a common executive administration. These companies are as follows:

1. The New York Edison Co.
2. The Brooklyn Edison Co.
3. The United Electric Light and Power Co.
4. The New York and Queens Electric Light and Power Co.
5. The Yonkers Electric Light and Power Co.

The latter two companies have no generating stations in operation but are supplied with energy from the stations of the three other affiliated companies. Altogether there are seven generating stations, with a total installed generating capacity on September 30, 1930, of 2,029,700 kw. Of this total, 896,700 kw. is in 25-cycle equipment and 1,113,000 kw. in 60-cycle equipment. With the addition of one new 160,000-kw. generator at Hudson Avenue Station this year and another next year the total capacity of the system will be raised to 2,237,000 kw. The 1930 peak load was 1,248,000 kw.

Generating Stations

The seven generating stations are designated as follows:

East River Station Waterside No. 1 & 2	of the New York Edison Co.
Hell Gate Sherman Creek	of the United Electric Light and Power Co.
Hudson Avenue Gold Street 66th Street	of the Brooklyn Edison Co.

Of these seven stations, East River, Hell Gate and Hudson Avenue stations are the newest and contain the most modern and efficient generators. All of these stations, however, have grown rapidly so that even in these modern stations there is a considerable difference in design, size and efficiency of the initial and the latest equipment. Hell Gate station, for instance, went into service in November, 1921, with two 35,000-kw. machines, whereas the last two units installed in 1928 were rated at 160,000 kw. each. When Hell Gate was first planned, an ultimate capacity of 310,000 kw. was decided upon. Some idea of the progress made in the ten years that have elapsed can be gained when it is considered that these last two units alone with a combined capacity of 320,000 kw. have a greater capacity than the originally planned capacity of the entire station. The total installed capacity of Hell Gate today is 605,000 kw.

What is true of Hell Gate in this respect is also true of Hudson Avenue, which was designed in 1922 to contain eight 50,000-kw. generators. At the present time, however, the last two units are being installed, each with a capacity of 160,000 kw. and when completed the station will have a total of 770,000 kw. generating capacity. This is nearly double the ultimate capacity of 400,000 kw. for which the station was originally designed.

East River Station, also known as "14th Street" because of its location at 14th St. and the East River, is the newest of all the New York Stations, having been placed in operation on November 23, 1926. East River was projected primarily to supplement the 25-cycle system but it was recognized that provision would also have to be made for the possible addition of 60-cycle equipment. In the meantime a frequency changer of large capacity was provided for conversion from 25- to 60-cycles and vice versa and for receiving or delivering energy to the connections with the Brooklyn Edison System. The fact that the station was intended largely for 25-cycle service led to the selection of its site. The continual growth of the 25-cycle demand with its center of load on the southern half of Manhattan Island indicated its location at 14th Street to present notable advantages.

So East River went into operation with two 60,000-kw. single shaft 25-cycle generators and a 40,000-kw. frequency-changer. Since then, in 1929, an additional 160,000-kw., 25-cycle generating unit has been added, giving the station a present total capacity of 280,000 kw.

Each of these three stations is quite different from the other two and represents different trends of engineering thought. Thus Hudson Avenue is a stoker station, East River a pulverized coal station and Hell Gate a combination of both powdered fuel and stokers.

Hudson Avenue perhaps is the most consistent of the three in its engineering development, for in its completed form it more nearly follows out the plans of those who originally designed it than do the other two. This will be brought out more clearly in a subsequent article when we discuss the development of these stations in greater detail.

The remaining stations on the system, Sherman Creek, the Waterside Stations 1 and 2, Gold and 66th St., are the older stations and while they are all still in use, their equipment dates back to the days when 35,000 kw. was thought to be the maximum capacity that could be attained in a single unit. None the less, these stations are important and while their economy is less than that of the newer stations, the equipment furnishes the bulk of the reserve generating capacity. In certain instances, the early machines in these stations have been replaced by more modern units. Thus Waterside, though built in 1901, has four generating units each of 35,000-kw. capacity.

In addition to the generating equipment installed in these stations, there is also provided in Manhattan storage battery capacity of approximately 100,000 kw. capable of carrying the direct current load for an appreciable time.

In these articles, no attempt will be made to describe any of these stations in detail. There would be no purpose in doing this since the older stations are to a certain extent similar so far as type of equipment is concerned. We shall, however, endeavor to show how advantage has been taken of certain new improvements as they become available.

It is interesting to trace developments, for instance, in a station such as Hudson Avenue, by comparing the designs of each successive installation. For although this station is only seven years old, the developments are quite obvious. In the turbine room at Hudson Ave., may be seen the large single shaft generating units of five years ago. This design was abandoned for cross-compound machines which made possible greater capacities than those attainable with single shaft machines at that time, due to the limitations in generator design. Later, greater experience with large units made possible the building of superior single shaft machines of which units 7 and 8 now being installed are examples. And so, in the boiler room, similar progress is evident.

In Fig. 4 is shown the generating and converting equipment installed in all the stations of the system. As will be noted, this equipment ranges from the old 5000-kw. vertical units of 25 years ago to the 160,000-kw. single-shaft turbo-generators of today. It was a far cry from the "Jumbo" dynamos of Pearl St. to the first 5000-kw. units at Waterside but the advance between the latter and the 160,000-kw. present day machines is almost as great if not greater.

System Operation

Before we discuss this phase of the system, it will be necessary to consider certain aspects of the system proper, the manner in which it is operated, the character of the load, how the load is allocated to different stations and what safeguards are provided to maintain continuity.

In general, there are three factors in the operation of the system which must be coördinated. These, in the order of their relative importance, are:

1. Reliability of service.
2. Quality of service.
3. Economy of production.

These three factors are inter-related and although reliability is placed ahead of quality and economy, it is evident that one depends on the other, so in discussing them we shall consider them collectively.

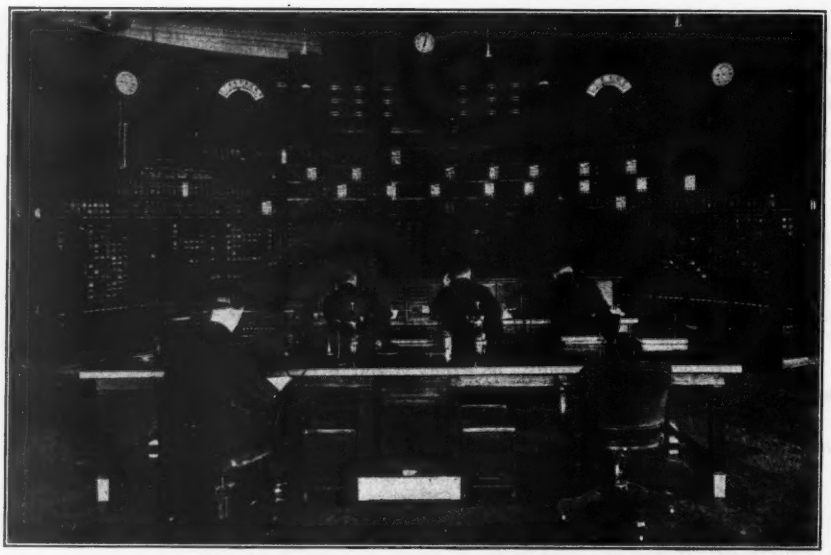
In the operation of any complex system requiring the coördination of a number of elements, the first requisite is centralization of control. The control of the New York Edison system is centralized in what is known as the System Operator's Office which is located on top of the Waterside Switchhouse building at 40th St. and First Avenue, New York City.

For convenience, the territory served by the affiliated companies of the New York Edison system is divided

FIG. 4. TABLE SHOWING THE CAPACITY OF THE GENERATING UNITS INSTALLED IN THE VARIOUS STATIONS OF THE N. Y. EDISON SYSTEM

GENERATING EQUIPMENT OF THE NEW YORK EDISON SYSTEM

			NO.1	NO. 2	NO.3	NO.4	NO.5	NO.6	NO.7	NO.8	NO.9	NO.10	NO.12	NO.18	TOTAL 25 ~	TOTAL 60 ~	TOTAL 25 & 60	FREQUENCY CHANGERS
EAST RIVER	14th ST. & EAST RIVER NEW YORK	60~															280 000	40 000
		25~	60 000	60 000		160 000									280 000			
HUDSON AVE.	HUDSON AVE. & EAST RIVER BROOKLYN	60~	50 000	50 000	50 000	80 000	110 000	110 000								450 000	450 000	35 000
		25~																
HELL GATE	134th ST. & EAST AVE.	60~	40 000			40 000		50 000	50 000	160 000	160 000					500 000	605 000	35 000
		25~		35000	35000		35000								105 000			
SHERMAN CREEK	201st ST. & 8th AVE.	60~	13 000	13000	13000	21 200	20 400	20 400								101 000	141 000	
		25~							20 000	20 000					40 000			
GOLD ST	GOLD ST. & EAST RIVER BROOKLYN	60~															124 500	
		25~	25000	25000	21000	30 000	11 000	12 500							124 500			
WATERSIDE NO.1	38th - 40th ST. ON EAST RIVER	60~												5000		5 000	214 000	40 000
		25~	35 000		35 000	20 000	9000	20 000		20 000		35000	35 000		209 000			
WATERSIDE NO 2	38th-40th ST. ON EAST RIVER	60~			14 000											14 000	152 200	40 000
		25~	30 000	22 200		14 000	12 000	12 000	12 000	12 000	12 000	12 000			138 200			
66th ST.	66th ST. & NEW YORK BAY BROOKLYN	60~	15 000	12 000	12 000	12 000	12 000									63 000	63 000	
		25~																
GRAND TOTALS															896,700	1,133,000	2,029,700	190,000



THE SYSTEM OPERATORS' BOARD

This is the "brain" or "nerve center" of the entire New York Edison System. From this room, the load is properly apportioned to the various generating stations and by means of this board the operators are made aware of every important event happening on the system.

into the following five districts: 1. Queens; 2. Brooklyn; 3. Manhattan and Bronx 25-cycle; 4. Manhattan, Bronx and Yonkers 60-cycle, and 5. Westchester.

In charge of each district is a group of men known as District Operators. These district operators in turn are under the centralized supervision of another group of men known as System Operators. The system operator is directly responsible for maintaining continuity of service at all parts of the system.

Through the system operator's office, the load is allocated to the various generating stations so that the greatest economy of operation will be secured. This function, that of economy of operation, however, is not directly in the hands of the system operator, but in that of a group of men known as the Economy Committee.

This committee advises the system operator by means of loading schedules, as to the division of load among the generating stations that will result in the lowest production cost of generation. These loading schedules are made up with consideration of those operating limitations that normally exist so that the system operator is able to follow the loading schedules and they may, therefore, be disregarded so that the system operator may devote all of his time to the function of supplying the system demand without interruption of service.

Centralized Operating Control

The system operator has the generating and distribution resources at his finger tips. In his office at Waterside Station is installed the electrically operated pilot board shown in Fig. 5. This board shows not only all the high tension equipment of the generating and distributing stations but also the feeders and ties between these stations. In addition a number of instruments on the board give certain essential data about the system as a whole.

The board is made of a welded steel framework with panels of asbestos wood. On the panel immediately below the clock are a series of bullseye lamps which indicate grounds on feeders and high tension lines of the generating stations. The attention of the system operator is called to the lighting of these lamps by a bell which rings at the same time that a lamp is lighted.

On either side of these lamps are totalizing wattmeters, indicating the power being transferred over the cables between various generating stations. Voltmeters and frequency indicators are also provided, indicating the voltage and frequency of the generating stations.

On the horizontal panels below these instruments, the high tension equipment of the various generating stations is shown. All of the switches in the generating stations are indicated on these panels in the relative positions in which they are placed in the stations. For each switch two lights are provided, a red light indicating the closed position of a switch and a green light indicating that the switch is open. These indications are transmitted automatically from the generating stations over telephone lines by means of a distributing supervisory system.

The bus tie switches connecting the various sections of the generating buses are shown by lamps set in white panels in those sections of the board devoted to generating stations. On several of these panels, there are additional lights, larger than the first which are "locater" lamps, their purpose being to call the attention of the operator to the operation of a switch in its section of the board. A bell ringing calls attention to the lighting of these various lamps. Thus, by these means, the operator is enabled to locate in the easiest and quickest manner, the exact panel in which a switch has been opened or closed.

High tension equipment in the various distributing stations is shown on vertical panels at the lower half of the pilot board, each vertical division being used for one distributing station. A red light is provided for each feeder, the light burning when the feeder is alive. There is a jack in each feeder panel so that jumpers may be placed between two feeders whenever they are tied in a distributing station.

Communication of the System Operator with various parts of the system and with the outside world is made through a telephone switchboard designed especially for this service and built into the Operator's desk. On the table behind the System Operator's desk is a second switchboard for the use of the Report Operator. Al-

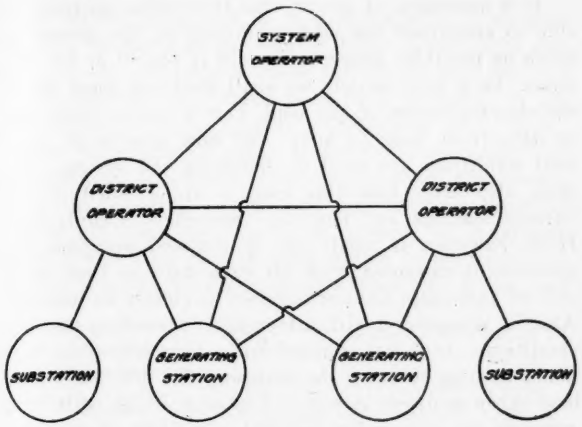


FIG. 6. SCHEME OF ORGANIZATION, SHOWING LINES OF COMMUNICATION BETWEEN SYSTEM AND DISTRICT OPERATORS, AND GENERATING AND SUBSTATIONS

though he works normally at the System Operator's desk, the Report Operator in case of emergency may have his telephone lines thrown to the second board where he can make reports to executives and receive and answer inquiries. Thus the System Operator is fully relieved of this work and his entire time as well as his switchboard is left free for the operation of the system. The report operator's board is so operated that he can listen in to the conversation of the System Operator or talk to any of the stations on the System Operator's board.

This System Operator's pilot board is perhaps the largest and most elaborate board of its type ever constructed, indeed its complexity and its cost is justified only by the great importance of the community it serves. In order to guard against an interruption of the telephone service in case of trouble on the telephone company's lines, the telephone wires are placed in four cables, each cable being routed through a different street.

In order to transmit orders quickly to the generating and distributing stations, an emergency signal set is provided. This consists of a standard fire alarm transmitter operated by a number of wheels, one wheel for each signal order. Leased telephone lines are used for these circuits and gongs and recorders in the stations receive the signals.

District Operator's Facilities

The System Operator, the Manhattan and Bronx 25-cycle district operators and the Manhattan, Bronx and Yonkers 60-cycle district operators are all located in the System Operator's room at Waterside and make use of the same facilities.

For the Brooklyn district, however, a separate board is provided in the Brooklyn Edison Building. This board shows a complete single line diagram of the Brooklyn Edison System, all switches and breakers being indicated by conventional squares which are punched to receive the different map pins which are used to indicate different system connections. This board is mounted on top of the telephone switchboard so that orders and instructions received and transmitted over the telephone system can be indicated on the board. This telephone switchboard is a specially constructed three position, multiple circuit board designed to handle the maximum number of calls between the district operator and the various stations, substations and consumers.

In full view of the District Operator and at right angles to the telephone board is the instrument board on which are mounted combination indicating and curve drawing instruments giving the District Operators instant visual indication of loads, voltages and frequency conditions in Brooklyn.

The Queens district operator also has a separate board. This is an elaborate type of manually operated, electrically-indicated board and shows a single line diagram of all the Queens substations and the transmission system. A monitor type telephone board faces this board.

The Westchester District Operator, however, does not use an indicating board but depends upon district points and diagrams for the necessary information required in operating his district. He is provided with a monitor type telephone switchboard.

The general scheme of organization, showing the lines of communication between system, district, generating station and substation operation is shown in Fig. 6. Only two district operators and two generating stations are shown, as the complete diagram with five district operators and seven generating stations would have so many lines crossing that it would be confusing.

The district operators are responsible for the energy distribution within their respective districts. They control all direct transmission feeders that supply the sub-

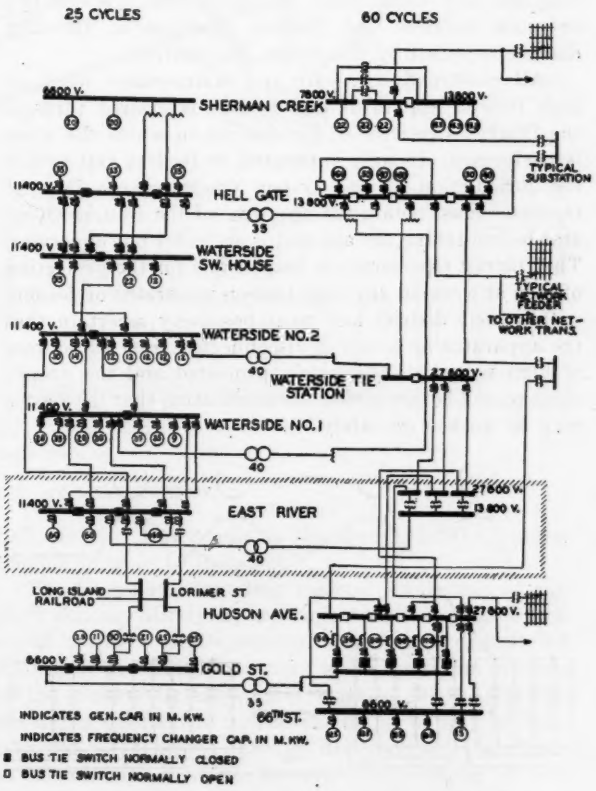


FIG. 7. SINGLE LINE DIAGRAM OF ELECTRICAL CONNECTIONS

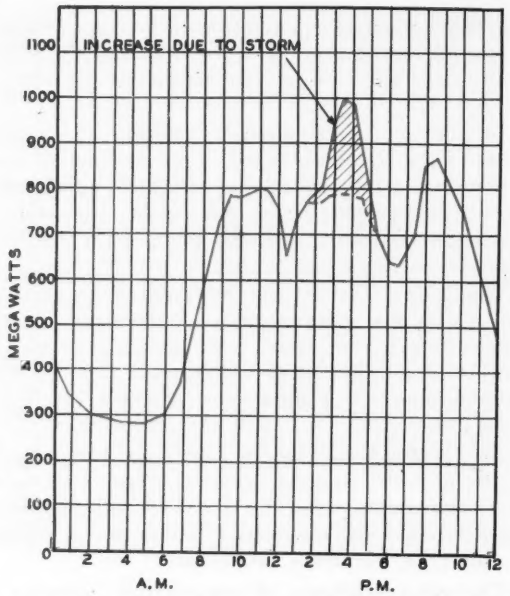


FIG. 8. LOAD CURVE OF THE N. Y. EDISON SYSTEM FOR SEPT. 2, 1930

station and low tension a.c. network in their districts. All high tension switching operation, except those assigned to the system operator, are performed at their direction.

Where feeders originate in a generating station of one district, but feed another district, the District Operator of the district being fed has control over the feeder switch at the generating station, provided the feeder supplies only his district. If the feeder supplies two or more districts, the District Operator of the first district supplied by the feeder has control.

All construction, repair and maintenance work on high tension apparatus and feeders is cleared through the District Operator of the district in which the work is performed. If such apparatus or feeders fall within the jurisdiction of the System Operator, the District Operator must obtain the approval of the System Operator before taking the apparatus or feeder out of service. The District Operators are responsible for the protection of men at work on any high tension apparatus or feeders within their district and must positively ascertain that the apparatus or feeder is disconnected from all sources of high potential, adequately protected and the proper signs placed before giving the notification that the feeder may be worked on safely.

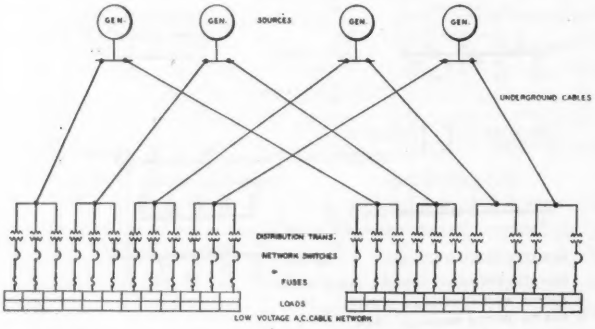


FIG. 9. SIMPLIFIED DIAGRAM OF SYNCHRONIZED AT LOAD SYSTEM

It is necessary, of course, that the system operator be able to anticipate the load conditions of the system as much as possible; hence, every aid is placed at his disposal. In a later article we shall study in some detail the characteristics of the load, how it varies from day to day, from hour to hour, and how studies of these load conditions are used in operating the system. We shall also show how this load is apportioned to the various stations and how the frequency is controlled. Here, however, it need only be pointed out that the operator is provided with all such data so that he is able to anticipate the normal load as closely as possible. Also, he is provided with information regarding weather conditions. It is not unusual for a thunder storm suddenly arising, to cause the addition of a 100,000 kw. of load in ten or fifteen minutes. Figure 8, which is the load curve of the system for September 2, 1930, shows what happened to the load on that day as a result of a thunder storm. The load, it will be seen, rose from about 800,000 to 1,000,000 kw. in one hour.

So much for the manner of operation; now what about the physical aspects of the electrical system itself? How are the various generating stations connected electrically?

Electrical System Connections

In Fig. 7 is shown a single line diagram of the electrical connections. The seven generating stations, it will be noted, are interconnected by means of tie feeders, which in each instance approximate the capacity of the largest unit. Five frequency changers tie the 25- and 60-cycle parts of the system together. The interconnecting or tie feeders serve a two-fold purpose: first they permit the interchange of energy between parts of the system in predetermined quantities so as to result in the lowest cost of generation and secondly, they make it possible to reduce the amount of reserve capacity on the bus to meet the emergency of the loss of one or more generating units.

The 25-cycle system is operated radially, the high tension feeders not normally being paralleled on the a.c. side of the rotary converters at the substations. The substations are usually supplied from more than one generating station to assure continuity and to facilitate load transfer.

The 60-cycle system is operated in parallel at the load, each bus section in a generating station being considered electrically as a separate station. This is the "Synchronized at the load" plan, which was fully described in a series of papers presented before the American Institute of Electrical Engineers several years ago.[1] This arrangement of connections has resulted in increased reliability of generating sources, lower interrupting duties on circuit breakers and reduction in service voltages, and during the time it has been in service has fully demonstrated its advantages as a plan of metropolitan supply. A simplified diagram of the arrangement is shown in Fig. 9. Each generator, it will be seen, is considered as an entirely separate source of generation and is connected to different parts of the load by separate feeders. Such a scheme of connections gives high reactance values for the synchronizing power circuits between the several generating units in comparison

[1] A.I.E.E. Transactions Vol. 48, No. 4, page 1079-1107.

to the values which are in general use with generators also synchronized at the station bus. Nevertheless, the main energy channels between generators and the load have reactances in respect to normal capacity, of the same order as those usually experienced with metropolitan underground cable systems. Thus, while this arrangement does not fundamentally affect the normal power distributing system, it does improve behavior during abnormal conditions. It makes the maximum short circuit current less than would be the case if a number of generators were concentrated on a single line.

	No. of feeders	Trans. Voltage	Cap. Kv-a.
Sherman Creek to Westchester...	2	45,000	50,000
Hell Gate to Westchester.....	2	132,000	60,000
Hell Gate to Queens.....	14	13,000 27,000	27,000
Hudson Ave. to Queens.....	7	27,000	107,000

It will be noted that the line from Hell Gate to Westchester operates at 132,000 v. This line is of particular interest because that portion of it running from Hell Gate to Dunwoodie is the first 132,000-v. underground cable to be installed.

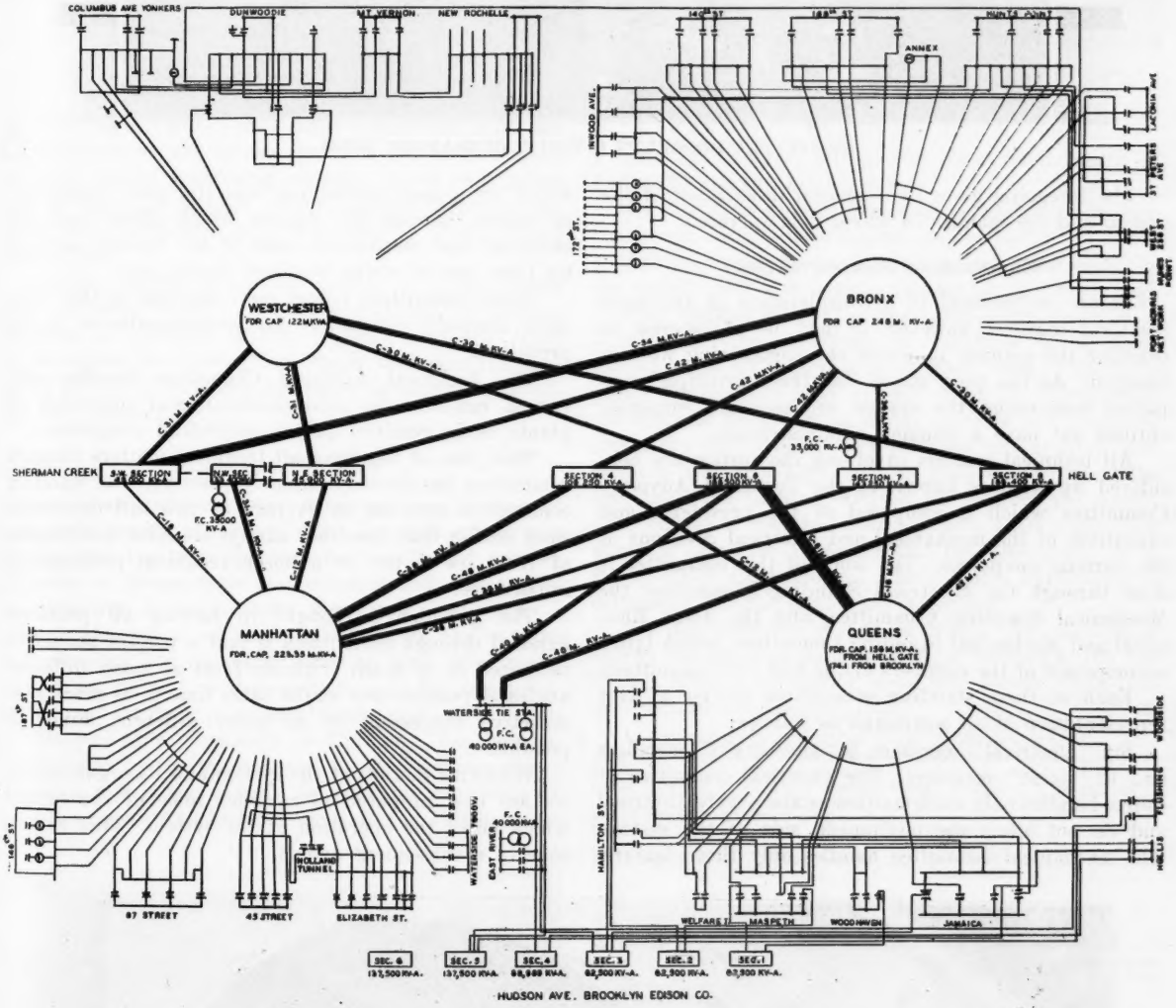


FIG. 10. THE SYNCHRONIZED AT LOAD SYSTEM

A schematic diagram of the entire synchronized at load connections is shown in Fig. 10. In studying this diagram, it should be kept in mind that only the 60-cycle system is involved in this scheme; hence, East River Station, which is a 25-cycle source, is shown only as a source of supply through the frequency changer, and this is true of Waterside and other 25-cycle sources.

Voltages at which the tie feeder and company interconnections operate vary from 13,000 to 132,000 v. The following table indicates the feeder connections between Queens and Westchester, which areas, as stated previously, have no generating sources.

The 60-cycle distribution load on Manhattan is supplied almost entirely by multiple feed low voltage networks having a total connected transformer capacity of 100,000 kv-a. Similar networks are in operation in parts of the Bronx, Brooklyn and Queens. Service to the remaining districts as well as the major supply to those networks is furnished through distribution substations. In the network districts, however, the building of new substations has been discontinued and the distribution transformers are supplied at generator voltage.

FIG. 11. THE BROOKLYN DISTRICT OPERATORS' ROOM

The foregoing gives us a general description of the system and the manner in which it is operated.

Engineering Administration

Before we proceed to a consideration of the more technical matters, however, it may be of interest to consider the manner in which the engineering work is handled. As has been stated, the three principal companies comprising the system are separate corporate entities but have a common administration.

All technical matters involving the *system* are considered by what is known as the Technical Advisory Committee which is composed of the presidents and executives of the mechanical and electrical divisions of the various companies. The work of this committee is done through the Electrical Standing Committee, the Mechanical Standing Committee, and the Joint Electrical and Mechanical Standing Committee, which latter is comprised of the members of the first two committees.

Each of these standing committees carries a joint representation of all companies as follows:

Six "electrical" members, 6 "mechanical" members and 12 "joint" members. The electrical committee of course handles only such matters as are purely electrical and do not affect the mechanical side of the system. The mechanical committee handles only those features which are purely mechanical and the joint committee, of course, handles all matters which affect both the electrical and mechanical sides of the system, such as tie lines, size of units, auxiliary drives, etc.

These committees report their findings to the Technical Advisory Committee for recommendation to the president.

The Technical Advisory Committee handles only system matters, the administration and operation of plants being retained in the individual companies.

This plan of handling all technical matters through committees has proved extremely effective. The standing committees meet on an average of two full days each week and in that time they always consider and dispose of from six to ten or a dozen technical problems of importance.

The president's thought in having all problems handled through committees is that a project should be subjected to as much criticism from as many different angles as possible and at the same time to as much constructive suggestion by as many different minds as possible.

With this picture of the system and its organization, we are now prepared to consider some of the factors which affect the operation of the system. This will be done in a subsequent article.

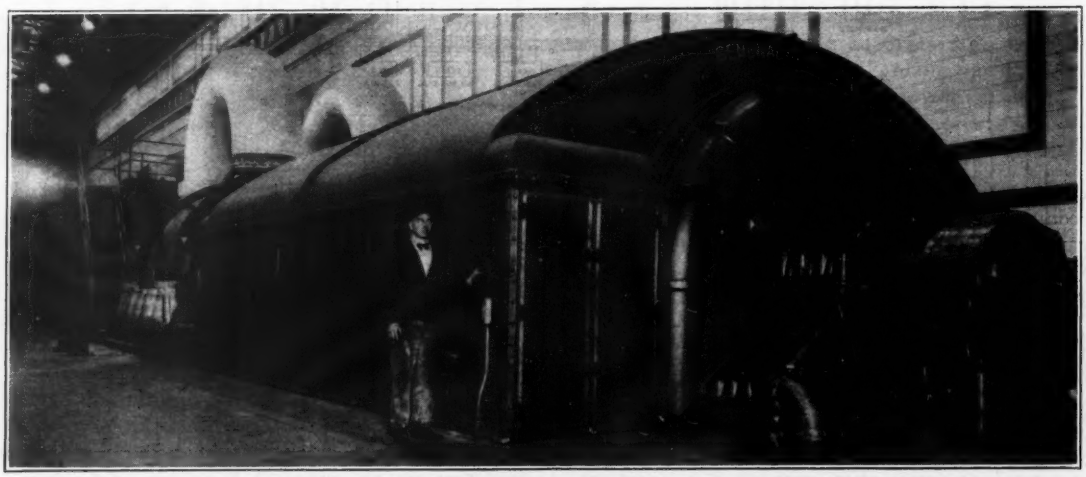
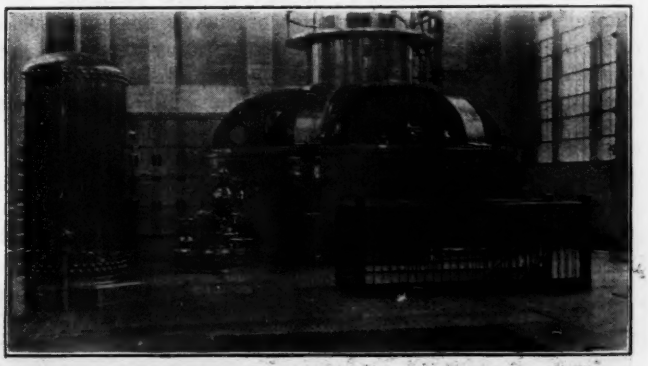


FIG. 12. THE 160,000-KW. SINGLE SHAFT GENERATING UNIT AT EAST RIVER STATION

Pumped Storage for Regeneration

By L. F. Harza



GENERATOR ROOM AT ROCKY RIVER. MOTOR PUMP AND TURBINE ARE ON THE LEVEL BELOW.

STORING ENERGY on a large commercial scale, has long been sought by the electrical industry in order to utilize steam generating capacity at off peak hours and in order to salvage surplus hydroelectric energy which would otherwise go to waste during times of high stream flow.

Storage batteries are too small, in commercially practical sizes, to enter into the generating and storing problems of modern utility systems, and the Ruth Accumulator for storing live steam increases the load factor on the boiler plant but saves no electric generating unit capacity.

European Practice

European engineers have developed one method of large scale storage of energy, which has been extensively applied and has been operated for a sufficient number of years to demonstrate its technical and commercial practicability, at least under European conditions. I refer to the use of off peak steam energy and surplus hydro energy for pumping water to high level reservoirs, from which it is drawn back again for regenerating current for daily or seasonal peak loads. Utilization of this principle, especially in Germany, has been so extensive as to challenge attention of American power engineers and it was largely second-hand knowledge of these developments which led the writer in 1930 to make a tour of Central Europe for first hand study of hydraulic storage applications.

FIG. 1. NIEDERWATHA PLANT FROM SURGE TANKS. 8-FT. AND 11.5-FT. PIPES 2600 FT. LONG. 470 FT. HEAD 5300 G.P.S. PUMPED 30,000 KW. GENERATED

In European installations, horizontal equipment predominates, usually with a pump on one end of the shaft, a combined generator and motor or generator-motor in the middle and a hydraulic turbine on the other end. During off-peak hours, the generator-motor operates as a motor driving the pump, the turbine casing being vented with air. During peak-load hours, either the pump casing is vented or the pump is disconnected entirely and the generator-motor operates as a generator driven by the turbine. Several installations have been made of vertical design with the generator-motor at the top, then the turbine, and at the bottom the pump. Also relatively few installations have been made with separate units for pumping and for generation, as at Rocky River, Connecticut. This requires duplication of equipment for the motor and generator.

To illustrate the extent to which this method of energy storage has been utilized in Germany, the following table is submitted, from the Escher-Wyss Bulletin of July-September, 1930.

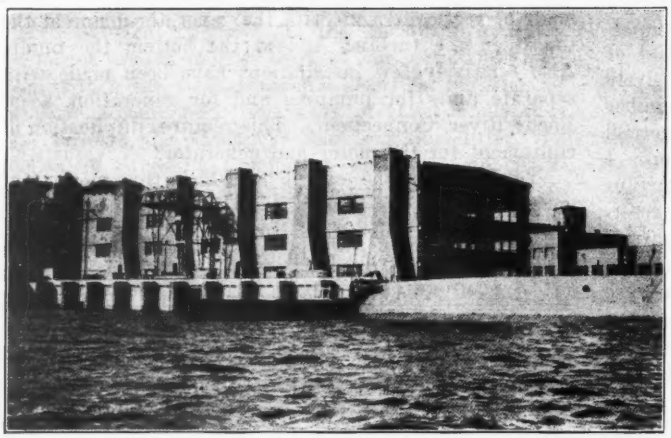
PUMP-FED STORAGE PLANTS IN GERMANY

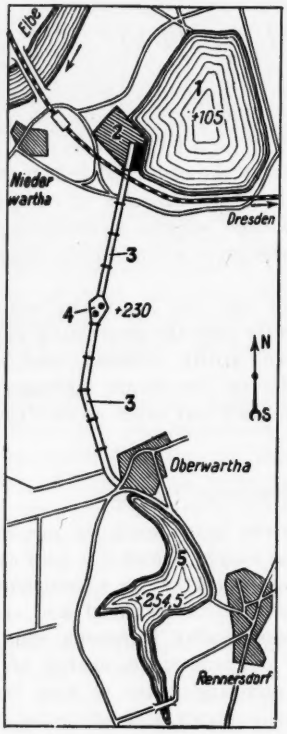
Plant	Turbine Output in HP	Pump Output in HP	Head Ft.	Layout	Remarks
Small Plants—Pump Storage Only					
Fridingen	2,250	1,860		Horizontal Combined	
Reutlingen	2,000	1,500	443	Horizontal Combined	
Mitweida	2,000	1,086	397	Horizontal Separate	Pumps driven by means of low pressure turbines.
Merkenbach near Giessen	2,470	1,620		Horizontal Combined	
Large Plants—Pump Storage only					
Niederwartha ..	120,000	100,000	485	Horizontal Combined	
Herdecke	194,000	102,000 136,000*	541	Horizontal Combined	*A fourth pump of 34,200 HP capacity will later on be added to the fourth machine unit.
Bringhausen	164,000	116,000	984	Horizontal Combined	
Pump Storage Supplementary to Hydro-Electric Development					
Zweribach Station	1,600	1,000		—Horizontal Combined	
Schwarzenbach..	62,500	25,100	738	Horizontal Combined	
Hemfurth	23,500	15,700	123	Vertical Combined	
Leitzach Station.		16,000	426	Vertical Separate	
Schluchsee	184,000	105,000	656	Vertical Combined	
Totals	758,320	623,666			

Note that in Germany a year ago the total pumping capacity in operation for storage of energy amounted to about 625,000 hp. and that the generating capacity installed with this pumping capacity to re-utilize or regenerate this energy was 761,000 hp., with further installations since that date and some ten more proposed. This compares with pumping installation to date in the United States of only two units of any importance, namely, at Rocky River, Conn., (see headpiece), combined capacity 16,200 hp.

stations even in this country, whether steam or hydroelectric. This method of storing energy has evidently gone beyond the experimental stage and has become an actual commercial reality on a large scale, enjoying the confidence of the utility executives and engineers and of the investing public.

It is worthy of note that the first three large stations—Niederwartha, Herdecke, and Bringhausen—have no natural high-head water supply, the only water available in their upper reservoirs for power generation being





A. GENERAL VIEW FROM ABOVE

B. POWER HOUSE, 120,000 H.P.

C. PLAN; 1 LOWER RESERVOIR, 2 POWER HOUSE, 3 PIPE LINE, 4 SURGE TANKS, 56 BY 115 FT. 5 UPPER RESERVOIR

Fig. 2. Niederwatha Plant, Dresden, Utilizes an Artificial Lower Storage Basin. Make-up Is from the Elbe River

This comparison is sufficient to challenge the attention of the American engineer, and American utility executives, at least to the extent of finding out whether we are overlooking a useful principle in the United States; whether differences in conditions in Germany and the United States account for the fact that this principle has not received greater recognition here, or whether it is the natural human inertia toward transplanting a European idea to American soil.

Large Plants Are of Various Types

It will be noted that German installations run to large size: Niederwartha, Figs. 1 and 2, 100,000 hp. in pumping capacity and 120,000 hp. in turbine capacity; Herdecke 136,800 hp. pumping and 194,000 hp. generating; Bringhausen, also Schluchsee nearly as large. These four would be rated as medium large generating pumped up with off peak and surplus power. They are pure pumped storage. In the case of Niederwartha also the lower reservoir is entirely artificial and make-up water is supplied to the lower reservoir from the Elbe River by a small pump. This represents the extreme effort which might need to be expended in order to apply the principle of pumped storage and regeneration, that is, both reservoirs being artificial with no natural water supply.

In the case of Herdecke, Fig. 3, the Ruhr River forms the tail bay but the upper reservoir is entirely artificial, built on the hilltop with concrete walls throughout.

The upper reservoir at Bringhausen is entirely artificial and of concrete, while the lower reservoir is created by a low-head hydro on a modest size stream.

At the Schwarzenbach plant in the Black Forest,

pumping is supplementary to power development; water is pumped from one high level reservoir, which is insufficient in capacity to store the available stream flow, into a higher reservoir which is more than sufficient to store the natural stream flow. Variations in the methods are many to accommodate local conditions.

Advantages

Some of the advantages claimed, evidently justly so, for hydraulic storage are as follows:

1. Permits operation of steam plants at load factor nearly equal to their availability factors and, therefore, with maximum economy and minimum fuel consumption per kw-hr.

2. Permits operation of an existing transmission line at nearly 100 per cent load factor between source of energy and center of distribution, thereby permitting more kilowatt-hours to be put over an existing transmission on line in 24 hr. than would be possible, if it carried its full capacity only during peaks.

3. Permits a given load to be served over high-voltage line from distant cheap hydro or coal field sources with generating and high line capacity, based on average instead of peak load requirements.

4. Furnishes standby service at load centers for cities supplied over a high-voltage line without the necessity of keeping boilers under steam and with no loss except negligible evaporation from the storage reservoir, also with less labor and maintenance cost than with steam.

5. May, under favorable conditions, provide lower investment cost for standby and peak load installation than for equivalent steam capacity, dependent upon whether favorable physical conditions are available.

6. Permits utilization of surplus hydroelectric energy which would be entirely wasted without storage.

7. Permits of quicker starting with hydro units for rapidly changing loads during peak-load hours and for emergency standby service than with steam.

8. Secures better coöperation and mutual helpfulness between steam and hydro operators on the system.

Disadvantages

Disadvantages of pumped storage and regeneration are as follows:

1. The principle is of limited application, dependent upon the existence of favorable local topography and sites for upper and lower reservoirs near the load center.

2. The principle entails a loss of energy by pumping and regeneration.

3. Emergency return of energy to the system as standby is limited to the energy equivalent to the water available in storage at the time. Steam could continue to operate indefinitely for the duration of an emergency, such as transmission failure, failure of hydro plant because of drought and the like.

4. Except in isolated places, will be located farther from load centers than steam.

It would seem that most of the above advantages and disadvantages are self-evident. Advantage No. 8,—better cooperation and mutual helpfulness between steam and hydro operators,—would seem to have importance in some systems by assisting the steam operators in making a good showing of operating economy and production costs of steam energy, thereby making them friends to the hydro plant. Too often they are unfriendly because, for the best results, a hydro must often operate so as to disorganize the operation of the steam plants on the system, causing them to show low operating economies.

Efficiency of Conversion

Operations at Niederwartha and at Rocky River seem to indicate that about 65 per cent of the energy

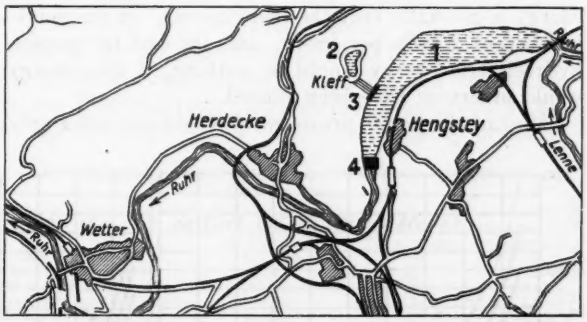


FIG. 3. HERDECKE STORAGE PLANT. A. PLAN; 1 STORAGE RESERVOIR, 2 UPPER RESERVOIR, 3 PUMP POWER STATION, 4 DAM AND MAIN POWER HOUSE. B. VIEW OF HERDECKE DEVELOPMENT AND CONCRETE UPPER RESERVOIR. C. INTERIOR OF POWER HOUSE

originally furnished by the high line to the pumping plant can be returned by regeneration to the high-line on peak loads and 60 per cent efficiency is believed to be safe all year assumption. This means that approximately 5 kw-hr. of off-peak or surplus energy can be repaid to the system by only about 3 kw-hr. at peak-load service. The difference in value between 3 kw-hr. of peak-load energy and 5 kw-hr. of off-peak or surplus energy must justify the installation, giving due weight, of course, to operating factors and in many cases to the fact that local standby service of some type might need to be provided in any event. The cost of off-peak steam energy is generally only the fuel expense,—in the neighborhood of 2 mills per kw-hr., and the cost for surplus hydroelectric energy would be nothing, if this energy would otherwise have been wasted.

Most of the points previously brought out refer only to daily storage plants where the pumps operate on the off-peak hours and the turbines return the energy to the system on the following peak; in other words, a 24-hr. cycle. There will be cases, especially in existing hydroelectric plants, where pumped storage can be added as supplementary to existing equipment, when the upper reservoir would be of sufficient capacity for seasonal storage. In this case, pumps could be run throughout the flood season of rivers having run-of-river hydro plants, thus giving to storage plants a great standby seasonal value in addition to the daily cycle of peak loads.

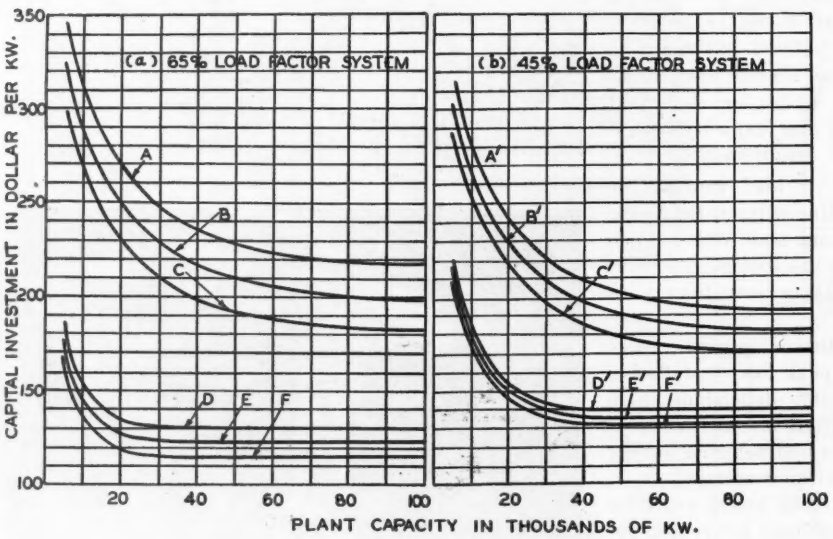


FIG. 4. ECONOMICAL LIMIT OF CAPITAL EXPENDITURE PER KW. OF INSTALLED CAPACITY OF PUMPED STORAGE PLANT. MARKWART

CURVES A, A¹, F, F¹, FOR $2 OIL OR $8 COAL CURVES B, B¹, E, E¹, FOR $1.50 OIL OR $6 COAL. CURVES C, C¹, D, D¹ FOR $1 OIL OR $4 COAL

CURVES A, B, C, A¹, B¹, C¹ ARE FOR PUMPS FOR OFF-PEAK ENERGY DRIVEN BY RUN-OFF-STREAM HYDRO POWER. CURVES D, E, F, D¹, E¹, F¹ ARE FOR PUMPS FOR OFF-PEAK ENERGY DRIVEN BY POWER FROM FUEL BURNING PLANTS

Economical Capital Expenditure Limit

Markwart, Transactions American Society of Civil Engineers, Volume 94, 1930, page 911, has contributed a scholarly, detailed discussion of the pumped storage and regenerating problems and has set up the following economic rule:

"The economic limit for capital expenditure for a pumped storage plant is the capitalized annual charges of a steam plant operating under similar load conditions as follows:

"1. In the event that the off-peak energy is supplied by run-of-steam hydroelectric plants, the limit will be the annual cost of a kilowatt-year of equivalent steam power (alternate steam peak load plant) capitalized at the annual percentage cost of hydroelectric plant.

"2. In the event that the off-peak energy is supplied by steam plants, the limit will be the annual cost of a kilowatt-year of equivalent steam power, minus the annual cost of the fuel burned to supply a kilowatt of pumped storage peak capitalized at the annual percentage cost of a hydroelectric plant."

Markwart has applied these principles to a number of assumed conditions, producing curves indicating the justified capital investment in dollars per kilowatt for pumped storage and regenerating plant; i. e., the economical limit of capital expenditure per kilowatt of installed capacity as a function of the size of plant and price of fuel which would be required for a competitive peak-load or standby fuel plant. One set of curves is for 65 per cent and another set for 45 per cent load factor. These curves are based on pure pumped storage, i. e., carrying the daily peak with water pumped during the previous off peak. They have reduced the broad general principles to their simplest terms for application in a general way to a case where the many local conditions and modifying conditions of a given situation are too little known to justify more detailed studies.

For a load factor of 45 per cent and $4 coal available for a competitive standby station, Markwart's analysis would arrive at a justified economical limit of capital expenditure per kilowatt pumped storage capacity, varying from around $180 for a station of about 10,000 kw. capacity to about $140 for a station from 40,000 to 100,000 kw. capacity and above. Each situation would be influenced by so many local factors that the foregoing can be taken only as a rough guide to the economics of pumped storage, under assumptions roughly representing Eastern United States conditions.

Conditions Which Limit Economy

Whether or not a pumped storage plant can be built at or near a load center depends, as previously stated, upon the availability of a suitable site. Where both

upper and lower reservoirs must be artificial, as in the case of Niederwartha, conditions are least favorable to the application of the principle, also in cases where only low heads are available. On the other hand, where a naturally favorable site exists for either or both reservoirs, or where the lower reservoir would be an existing river, as at Herdecke, the opportunities of development become more favorable.

Where a hydroelectric power plant of medium head already exists at or near a load center, with upper and lower reservoirs already in service for generating hydroelectric power, the addition of pumping and additional generating capacity offers the greatest prospect of economically justified application in the United States. Thus for a head of about 225 ft., the cost of adding merely pumping and generating capacity to an existing hydroelectric plant would, in general, be in the neighborhood of about $75 per kilowatt of generating capacity, including therein the cost of the pumping capacity. This is approximately 55 per cent of the justified investment of $140 on the general academic basis, as presented by Markwart, without knowledge or consideration of the many local influences which would govern a decision in any given specific instance.

Whether the difference in cost between $75 per kilowatt for an installation with existing forebay and tailbay reservoirs and $140 per kilowatt justified or $65 would pay for development of upper and lower reservoirs, pipe lines, acquisition of land and other expenses is a matter to be determined in any specific instance.

Utilities, however, serving cities with difference of elevation in or near the city of 100 ft. or more may well study the possibilities of pumped storage and it is possible, even probable, that situations would be uncovered where developments could be made at costs fully justified and advantageous as compared with peaking by steam. Also it is to be expected that possibilities of seasonal storage would be uncovered, which might give to pumped storage plants a greater standby value over a longer period, as for example in case of transmission line failure, or a drought affecting hydroelectric plants.

District Heating in Pittsburgh

DATA ON THE district steam heating system in Pittsburgh and the Allegheny County Steam Heating Co. were given in a recent issue of Byllesby Management. Pittsburgh has a large number of buildings located on a comparatively small ground area; 67 per cent of the heating load is furnished to office buildings or other similar buildings, such as large departments stores and hotels. Details of the classification are shown by the table.

About 90 per cent of the steam is used for space heating and the remaining for water heating, cooking, laundering, dairy, and meat packing industry. Seventy-eight per cent is sold to customers whose annual consumption equals or exceeds 8,000,000 lb. a year, although a large number of the customers are small users, 113 of them consuming 1,000,000 lb. a year or less. All service is metered either in the form of steam or condensate and a uniform rate is applied to all steam sold. This is a step rate consisting of seven steps varying between a minimum of 50,000 and a maximum of 3,000,000 lb. a month.

The 3,000,000 sq. ft. of heating surface served has a potential demand of approximately 900,000 lb. per hr. Actual peak demands of individual buildings come at different hours, however, so that the diversity brings the system peak to about 65 per cent of the foregoing. About 80 per cent of the steam is distributed at an average pressure of about 12 lb. gage and the remaining pressure at about 125 lb. gage.

Low-pressure steam is distributed from the Stanwix plant in which a 6250-kv-a. back pressure turbine acts as a reducing valve, reducing steam from the boiler header at 200 lb. gage down to 10-25 lb. gage pressure. The principal supply of high-pressure steam comes from the new Twelfth Street plant where it is generated at 250 lb. and delivered to the distribution piping pressures varying between 125 and 175 lb. The principal distribution piping is installed in tunnels. In the interest of reliable continuous service, spare steam generating capacity is maintained at all times equivalent to the maximum output of the largest boiler.

DETAILED CLASSIFICATION OF STEAM HEATING CUSTOMERS

	Sq.Ft. of Connected Radiation	Per Cent of Total Load	Number of Customers
Hotels	430,000	14	9
Department stores	357,000	12	8
Office buildings	1,285,000	43	64
Theaters and churches	166,000	6	14
All other	762,000	25	147
Total	3,000,000	100	242

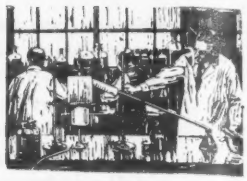
Natural Gas Pipe Line, Texas to Chicago

FORD, BACON & DAVIS, INC., engineers, has been awarded the contract for construction of the last section of the world's longest natural gas pipe line which extends more than 950 mi. from the Texas Panhandle to Chicago. The last or seventh link of this project, running from Rock Island to Joliet, Ill., will be 155 mi. long and the contract provides for its completion on or before July 1.

The seventh section will be made of 24-in. pipe, the standard size employed throughout the line and will cross the Fox River and the Illinois-Mississippi Drainage Canal. At Joliet the line will connect with the Chicago Belt Distribution System which serves greater Chicago and adjoining territory.

The Rock Island section is the second to be contracted for by Ford, Bacon & Davis, Inc. The other section extended 140 mi. through a portion of Kansas, running almost to the Missouri River, making a total of 295 mi. to be constructed by these engineers.

When completed, the Texas-Chicago line will serve natural gas to about 50 cities and towns along its route. Estimated reserves of the line are 7,000,000,000,000 cu. ft. These reserves are the property of the nine large utility and oil companies which formulated the plans of the project and organized the Continental Construction Co. These companies are Cities Service Co., Standard Oil Co. of New Jersey, Insull & Son, Inc., Texas Corp., Columbian Carbon, Skelly Oil Co., Phillips Petroleum Co., Southwestern Development Co. and United Carbon.



Significance of ALKALINITY *in* EMBRITTLEMENT STUDIES—*Part I*

Current A. S. M. E. ratio formula for inhibiting embrittlement requires reconsideration and revision. Conventional alkalinity determinations are sufficiently accurate for natural untreated but not for testing boiler waters. These conclusions are justified by the authors in Part I, while in Part II they present the derivation and graphical solution of a ratio formula which considers all inhibitors which may be present.

By Max Hecht
Chief Chemist
and
D. S. McKinney
Chemical Engineer

Power Stations Dept.
Duquesne Light Co.
Pittsburgh, Pa.

BOILER WATER CONDITIONS are stressed in many discussions on that phase of boiler metal cracking termed embrittlement. Principal factors discussed include the so-called alkalinity of the water and the maintenance of the A.S.M.E. recommended inhibiting ratios. Published discussions on this subject do not disclose that the investigators have recognized the significance of the following pertinent questions:

a. Do the applied test methods for determining the so-called "soda" alkalinity permit the correct interpretation of the alkaline conditions of the boiler water?

b. Are the current published A.S.M.E. recommended ratios of sodium sulphate to soda (methyl orange) alkalinity[1] formulated correctly for present day operating conditions?

Discussion on Inhibiting Ratio Formula

The following extracts from current literature are reproduced to focus attention to the limitation of the existing ratio formula, and to the test methods used for the chemical control of the ratio and also boiler water treatment.

Considering the A.S.M.E. recommended ratio[1]:

"In view of the particular cases of embrittlement cited above and pending further research, the maintenance of not less than the following ratios of sodium sulphate to the soda (methyl orange) alkalinity is recommended as a precautionary measure:

Working Pressure of Boiler, lb. ga.	Relation of Sodium Carbonate	to	Sodium Sulphate
0 to 150	1	to	1
150 to 250	1	to	2
250 and over	1	to	3"

The A.S.M.E. recommended ratio formula does not recognize the inhibiting characteristics of the inhibitants—carbonate and soluble phosphate or other materials suggested by Straub. Straub states in Bulletin 216[2] on page 95. (Italics have been added for emphasis; they do not appear in the original.):

"Embrittlement in boiler plate is caused by the combined action of stress and chemical attack. The stresses are inherent in the construction and operation of the boiler while the chemical attack is caused by the presence of *sodium hydroxide* in the boiler water."

"The presence of *sodium sulphate* in the boiler water tends to retard the embrittling effect of the *sodium hydroxide*, and, if in proper proportions, will stop it entirely."

"The presence of *phosphates*, tannates, chromates, nitrates, acetates, etc., will also inhibit embrittling action of caustic soda, if these salts are present in proper amounts."

Concerning the inhibiting effects of sodium carbonate and sulphate, Straub states, on page 69[2]:

"On comparing sodium sulphate with sodium carbonate as to solubility in *sodium hydroxide*, it is found that these two salts are similar in this respect. This fact coupled with the knowledge that *sodium carbonate* in solution will not produce embrittlement, appears to indicate that the *undecomposed carbonate* in a boiler might also act as an inhibitant."

and further, it is stated on page 81:

"The phosphate radical appears to be 1500 times as effective as the sulphate radical."

Referring specifically to Straub's laboratory experiments, they appear to produce evidence that *highly* concentrated solutions of *caustic soda* act on boiler metal when stressed. The results of the tests using inhibitants appear to show the effectiveness of the materials for retarding the chemical attack. The results of Straub's laboratory tests, Table 23, page 69, appear to support the view quoted above from page 69. The authors note from their own experience that the carbonate ion concentrations, i.e., undecomposed carbonate, change but slightly during the operating run of a specific boiler.

[1]Suggested Rules for the Care of Boilers, Section VII, A.S.M.E. Boiler Construction Code, 1926. American Society of Mechanical Engineers, par. C, A-5.

[2]Embrittlement in Boilers, Frederick G. Straub, Bulletin No. 216, Engineering Experiment Station, University of Illinois, Urbana, Ill., October 21, 1930.

¶ Purposes of this article are to indicate the inadequacy of the conventional alkalinity methods; to show the futility of applying data derived from these methods to establish ratios for inhibiting embrittlement and the development of a method for the correct evaluation and distribution of the alkaline ions in water. A ratio formula which considers all of the inhabitants present in the water is suggested.

In the opinion of the authors, the evaluation of carbonate as potential hydroxide, inferred from the A.S.M.E. recommendations, is incorrect.

Hall, in his privately distributed methods, considering the phenomenon of boiler metal cracking, interprets the hydroxide and carbonate ions as contributing to boiler metal cracking. He introduces into his developed formula for inhibiting boiler metal cracking, an empirical correction for the alkalinity conferred by the presence of soluble phosphate in the boiler water. The authors, in their boiler water control work, have noted repeatedly a minus numerical value for alkalinity in phosphate treated water, when this empirical correction was applied to the test data obtained by the Winkler method. The use of any constant empirical correction is not valid since the magnitude of the phosphate correction is a function of the pH value of the boiler water. This is concluded from the use of equilibrium data.

It will be shown, both in view of the extracts referred to and the data submitted herewith, that the current A.SM.E. recommended ratio formula requires reconsideration and revision. The development of a formula is implied in which the inhibiting ions in the boiler water should include sulphate, carbonate and phosphate. A constant should be assigned to each ion representing its effectiveness as an inhibitor for various concentrations of total boiler water salts and boiler operating pressure. The hydroxide ion, as Straub implies, should be designated as the single boiler water factor causing embrittlement. If the results of Straub's laboratory embrittlement tests are considered, then in the suggested formula, carbonate and sulphate should be given equal weight, and phosphate should be rated considerably more effective than either of these inhibitants.

What are the maximum concentrations of hydroxide ion permissible in boiler waters for various concentrations of total boiler water salts and for various boiler pressures? The minimum requirements are those necessary to complete effectively the reactions for the removal of scale forming compounds, plus some hydroxide to arrest corrosion. It has been believed that corrosion of boiler metal would be practically arrested in water having a pH value of 9.6 (measured at room temperature). This value corresponds to a hydroxide concentration of 0.68 p.p.m. The pH value of pure water saturated with ferrous hydroxide is 9.6[3]. This value has been applied in corrosion prevention work at room temperatures. In the plant control work under the supervision of the authors, the repeated inspections of the water-wetted surfaces of the boilers show the elimination of the rust appearance when the boiler water possessed a pH value of at least 10.6, the samples tested at room temperature. This value corresponds to a concentration of 6.8 p.p.m. of hydroxide ion. Research is required to determine if scale elimination and corrosion prevention can be secured effectively at various boiler pressures, maintaining the hydroxide ion concentration indicated by the pH range of 10.6 to 11.2, with the pH value measured at room temperature.

Testing Methods

Consideration must be given to the correctness of the testing procedures before revising the ratio values. The estimation of the hydroxide ion is logically made by using the relation of the hydroxide concentration, in

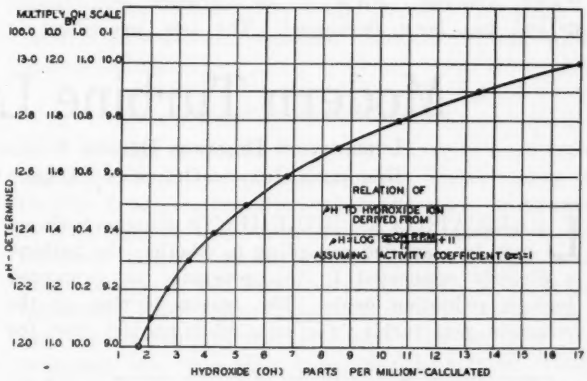

MULTIPLY OH SCALE BY
100.0 10.0 1.0 0.1
13.0 12.0 11.0 10.0
12.8 11.8 10.8 9.8
12.6 11.6 10.6 9.6
12.4 11.4 10.4 9.4
12.2 11.2 10.2 9.2
12.0 11.0 10.0 9.0
pH - DETERMINED
RELATION OF
PH TO HYDROXIDE ION
DERIVED FROM
ASSUMING ACTIVITY COEFFICIENT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
HYDROXIDE (OH) PARTS PER MILLION - CALCULATED

FIG. 1. RELATION OF HYDROXIDE CONCENTRATION TO THE PH VALUE OF WATER

parts per million, to the pH value of the water. This relation is shown graphically in Fig. 1, and its formulation is shown in Appendix A. When the hydroxide concentration is thus determined, no correction is required for the presence of other alkaline-conferring ions present in the boiler water. The determination of the sulphate and soluble phosphate is made by the usual procedure[4].

Soda (methyl orange) alkalinity for the A.S.M.E.

APPENDIX A.—RELATION OF pH AND HYDROXIDE IN PARTS PER MILLION

Since $pH = \log \frac{1}{H^+}$, and $H^+ \times OH^- = 10^{-14}$

and if OH is expressed in millimols per liter, then

$$\frac{H^+ \times OH^- \text{ in millimols}}{10^{-3}} = 10^{-14} \quad (1)$$

Or

$$H^+ = \frac{10^{-11}}{OH \text{ millimols}} \quad (2)$$

Or substituting values of Eq. 2 in Eq. 1.
Then

$$pH = \frac{\log OH^- \times \text{millimols}}{10^{-11}}$$

$$= \log OH^- \text{ millimols} + 11$$

Since 1 millimol OH = 17 p.p.m. OH
Then

$$pH = \frac{\log OH \text{ p.p.m.}}{17} + 11 \quad (3)$$

The curve, Fig. 1, was constructed from the formulation, Eq. 3.

[3]Corrosion, Causes & Prevention, F. N. Speller, McGraw-Hill Book Co., 1926 footnote on page 403.
[4]National Electric Light Association Publication No. 14, Power Stations Chemistry, January, 1931, pages 24 and 25. Also the National Electric Light Association Publication No. 289, Power Stations Chemistry, Part II, August, 1929, page 18.

ratio formula[1] is determined by the alkalinity method, Standard Methods of Water Analysis, American Public Health Association[5] which applied to boiler water analysis is inaccurate. The Chemists Subcommittee, Prime Movers Committee, N.E.L.A., commenting on the method, said[6]:

"The alkalinity here described may be considered sufficiently accurate for natural waters untreated; however, the results obtained by this procedure when testing processed water either thermally or chemically treated, and boiler waters, may be in error."

The Winkler Alkalinity method[6,7] has been proposed as an alternative method. It is used by some workers in boiler water control to overcome the recognized inaccuracy of the A.P.H.A. method. It will be shown that this method is incorrect. One of the authors[8] has completed a physico-chemical study on the Interpretation of Water Analysis. From it an abridged equilibrium method has been developed. The test procedure is simple, the data obtained are accurate. The data obtained by the method permit the correct distribution and interpretation of the following ions in water: bicarbonate, carbonate, and the free carbon dioxide (if present). This method when applied to boiler water chemistry permits one to determine and evaluate correctly the ions necessary for use in the inhibiting ratio formula. The equilibrium method when applied to boiler water treatment problems in general, permits a more rational solution than can be made by the use of the two test methods referred to above. (To be continued.)

[5]Standard Methods of Water Analysis, American Public Health Association, 6th edition, page 32.

[6]See reference 4, Publication 14, page 15.

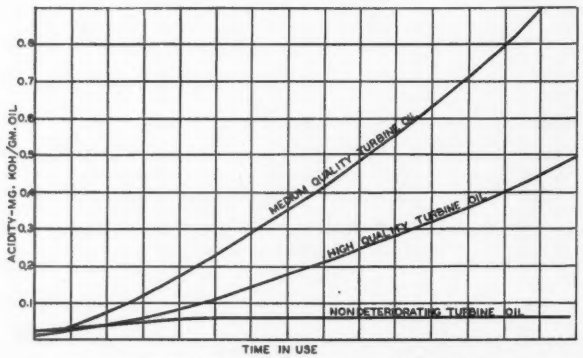
[7]See reference 4, Publication 14, page 16, also a Physico-Chemical Study of Scale Formation and Boiler Water Conditioning, Page 162.

[8]D. S. McKinney's manuscript — Interpretation of Water Analysis, Equilibrium Considerations of the Ions of the Slightly Dissociated Acids, H_2CO_3, H_3PO_4, etc., has been accepted for publication at an early date in one of the national chemical publications.

Modern Turbine Lubrication Practice

LUBRICATION DEMANDS DEPEND SOMEWHAT ON DESIGN. A GEARED UNIT WILL REQUIRE A HEAVIER OIL THAN A DIRECT CONNECTED UNIT. BY W. F. FITZGERALD*

LUBRICATION REQUIREMENTS of steam turbines may be classified according to whether the turbine is directly connected to the generator or connected through reduction gears. The reason is that in the reduction gear turbine the same oil is usually used for the gear mechanism and the turbine bearings. This condition puts demands on the lubricant that are not encountered in the direct connected machine. Lubrication of the two classes of turbines is identical in many respects, however, so reference will first be made to the direct connected turbine with exceptions given later for the gear reduction class.



ACIDITY OF TURBINE OIL IN SERVICE

These curves show typical changes in acidity and rate of separation from water which takes place during use under identical conditions. The time interval is not shown because the time required for any given amount of deterioration depends (for the same oil) on severity of conditions. From six months to six years might be required for the changes shown on these curves but regardless of the time, the three oils will compare as shown above.

*Technical Division, Standard Oil Co. of Indiana.

Direct connected turbines, with few exceptions, employ either ring oiled bearings with oil reservoir or a circulation system fed from a gravity tank or by a pressure pump. Lubrication of ring oiled bearings on turbines is not unlike that of general bearing lubrication, while, with circulation systems, the problems arise with which we are most concerned at this time.

Generally, in a circulation system, the oil returns from the bearings to a reservoir by gravity. It is pumped from the reservoir through a cooler back to the bearings, thus giving a complete cycle. This is modified with various conditioning systems, such as filters, centrifuges and settling tanks. In a gravity tank system, the oil is pumped to a tank and flows from there to the bearings by gravity. In practically any modification of the circulation system, the demands on the oil are such that similar problems arise in maintaining it in satisfactory condition. These vary, of course, with

TABLE I. OPERATING DATA FROM INSTALLATIONS USING A NONDETERIORATING TURBINE OIL

Plant	Turbine No.	Make	Size K. W.	Speed R. P. M.	Filter	Time in Use—Mo.	Fill Gal.	Make-up Gal.	Bearing Temp.	Color N. P. A.	Acid Mg. KOH/gm.
A	1	A-C	7500	1500	Cont.	18	385	150	115—35	1½—2	0.04
A	2	A-C	7500	1500	Cont.	21	420	180	120—40	1—1½	0.04
A	3	G-E	7500	1500	Batch	1½	....	...	90—95	1—1½	0.05
B	3	G-E	1500	....	Cont.	16	33	17	125—65	1½	0.04
C	2	G-E	1000	3600	None	16	30	40	155	1½—2	0.01
C	P.	G-E	1250	3600	None	19	35	93	145—50	1—1½	0.04
C	3	G-E	1250	3600	None	16	30	34	155	1½—2	0.02
C	5	A-C	5000	3600	Cont.	6	....	18	103—25	1—1½	0.03
C	6	A-C	5000	3600	Cont.	4½	....	14	114—24	1—1½	0.04
D	30	A-C	7500	1500	Batch	7	200	None	110—20	1½—2	0.04
D	31	A-C	7500	1500	Batch	14	230	100	108—20	1½—2	0.03
D	40	A-C	15,000	1500	Cont.	6	2200	...	134—36	1—1½	0.03
D	42	G-E	30,000	1500	Cont.	14	2000	None	110—20	1—1½	0.02
D	41	A-C	15,000	1500	Cont.	5	2200	...	130—40	½—1	0.03
E	..	G-E	1200	....	None	9½	25	1/wk.	154—82	1½—2	0.05
F	7	G-E	5000	3600	None	5	128	5	140—66	1½	0.07

NOTE: Temperatures are approximate. Make-up is total to time of last analysis.

TABLE II. TYPICAL SERVICE PERFORMANCE OF A HIGH GRADE TURBINE OIL

Plant	Turbine No.	Make	Size K. W.	Time in Use	Color N. P. A.	Acidity
A	2	A-C	7500	7½ Mos.	4½—5	0.75
G	..	G-E	10,000	19 Mos.	4½	0.24
F	7	G-E	5000	(*)	5½—6	0.50
H	3	W	10,000	12 Mos.	4½	0.40
B	6	A-C	5000	6½ Mos.	4½	0.21
H	..	G-E	1500	4 Years	4½	0.44
D	41	A-C	15,000	18	5	0.86
D	40	A-C	15,000	18	4¼—5	0.43

*Oil never completely changed. Large replacement, as turbine oil is taken from system for general engine lubrication.

such factors as bearing temperatures, rate of circulation of the oil, quantity of oil in the system and conditioning system, but in general the same problems arise, varying only in degree.

The major problem encountered with turbine oil is sludging or the formation of insoluble material which in the presence of water causes very persistent emulsions. Oil foaming and oil losses due to atomization are at times serious, but usually can be overcome by altering mechanical conditions and methods of handling lubricants.

If air, hence oxygen, could be excluded from the oil circulation system, little or no change would be encountered with the usual turbine oil. This change in the oil, then, is one of oxidation and the formation of materials which, if not removed, will cause trouble. Oxidation of turbine oil is shown by the formation of asphaltenes, free acid and saponifiable material. The asphaltenes are only slightly soluble in turbine oil at moderate temperatures and are strong emulsifying agents. Although the acids are emulsifying agents, their effect as such is minor, but they do form soaps by action on metals, particularly iron and copper. The soaps will form emulsions, in the presence of water, of similar type to emulsions formed by asphaltenes, the persistency of which will depend mostly on the amount of the materials present. Both the asphaltenes and metal soaps can be settled out by lowering the temperature of the oil as in cooling coils and settling tanks; however, if the system is kept free from water, these materials are considered not deleterious until large amounts are formed.

Turbine Oil Tests

Darkening in color, increase in viscosity and formation of sludge are probably the most readily discernible changes in turbine oils. Changes in color and viscosity are not particularly harmful in themselves; they are, however, indicative of a gradual oxidation taking place. Tests for acidity and demulsibility are probably of most value, as the measure of acidity indicates the formation of acids which in turn form strong emulsifying agents. The value of acidity is usually given in milligrams of potassium hydroxide required to neutralize the acid in one gram of oil and is usually written as mg. KOH per gram. Authorities differ considerably as to the maximum allowable limits of acidity in turbine oil. Conservative operators change oil or take measures to lower the acidity when values of 0.5 to 0.8 mg. KOH per gram of oil are reached.

The Steam Emulsion (S. E. number) and Herschel Demulsibility (H. D.) are two widely used tests for determining the rate of separation of oil from water. These tests, although valuable when used within certain limits, are influenced by unknown factors to the extent that results, even by experienced operators, vary considerably.

Satisfactory turbine operation is approached by removing undesirable accumulations either by settling, filtering or centrifuging, or by a combination of these methods. This, however, is expensive and shutdowns are necessary at frequent intervals in order to change oil and to clean the oil pipes, coolers, reservoirs and filters. Operating costs are enhanced by forced shutdowns due to excessive sludging, loss of oil due to deterioration, loss of oil in cleaning the system, and the hidden costs. These latter would include such items as production losses and overhead losses due to time spent in shutdowns.

Preventive Measures

A solution of this problem would have to come from one or both of two possible sources; improvement in turbine design, or improvement or change in lubricants. It is fairly well agreed that the change must be in the lubricant rather than in turbine design. In line with this demand, a nondeteriorating turbine oil is being marketed. Table I gives operating data on this product used in sixteen different turbines. The acidities are extremely low even after many months service. Table II gives operating data on an ordinary high grade turbine oil. The plant letters represent the same plants in both tables. The curve shows in graphic form the change in acidity in two well known brands of ordinary type turbine oil and in a nondeteriorating turbine oil. Although the maximum time in use shown in Table I is 21 mos., the actual time at present is more than 3 yr. in some of the plants yet no further increase in acidity is found. The result is that the user is freed from sludging troubles.

Geared Turbines

In those cases where the same oil is used for both gear mechanism and turbine bearings, it is necessary to use a heavier oil because of the higher pressure due to line contact in the gear teeth. The main problem is to choose a product sufficiently high in viscosity to withstand the gear service, yet not too heavy for the bearings. The same general problems arise from deposits as considered in connection with direct connected turbines.

Hydraulic Turbines

Although the types of bearings encountered in hydraulic turbines are considerably different in many cases from those of steam turbines, the lubrication problems are quite similar. The sludging tendencies are lessened, due to a smaller amount of heat, less surface of oil exposed to heated air and less chances for contamination with water and impurities. Removal of deposits at frequent intervals is necessary regardless of the type of bearing or method of supplying oil.

Steam Piping for 1000 Deg.*

Features of Detroit Edison Co's Installation at Delray

What 1000 Deg. Requires in Design

*By J. H. Walker***

BECAUSE, with steam temperature of 750 deg. F. at pressures above 450 lb., it is necessary to reheat at some stage of expansion to avoid excessive moisture in low-pressure stages, use of higher temperature steam is sought so that the simple regenerative cycle can be employed without reheating. At Delray, a 10,000-kw. turbine plant is under construction to use 1000-deg. steam in the effort to determine the feasibility and difficulties of this forward step in steam practice.

Three factors present problems. 1. Tensile strength drops rapidly at temperatures above 700 deg. F., as indicated in Fig. 1. 2. At 1000 deg. most metals are subject to considerable continuous deformation under stress or "grows." This plasticity or creep must be taken into account. 3. At high temperatures dissociation of steam into hydrogen and oxygen takes place to a considerable extent with resultant oxidation of surfaces exposed to the steam.

Objects sought in the piping design were: First, safe and reliable installation. Second, test of various materials and joint designs to obtain information for use in future installations.

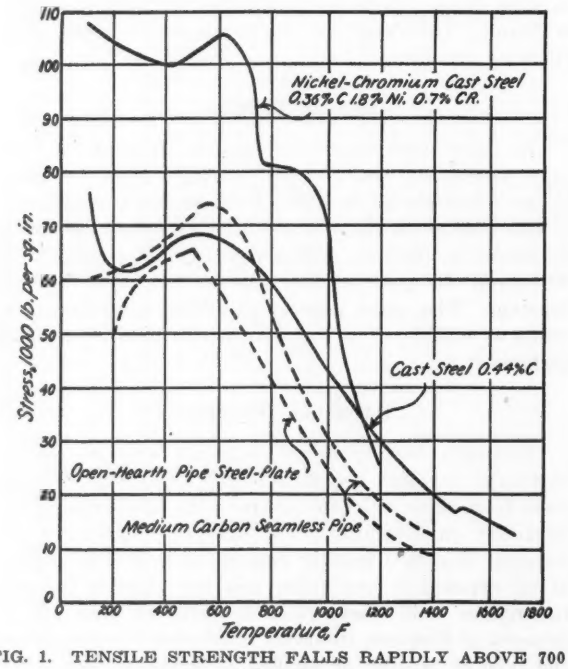


FIG. 1. TENSILE STRENGTH FALLS RAPIDLY ABOVE 700 DEG. F.

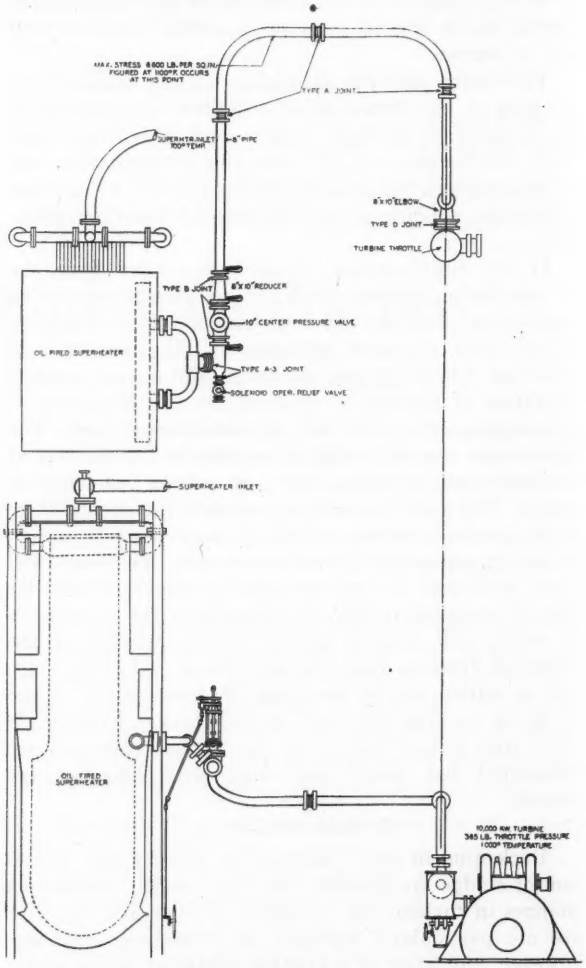


FIG. 2. PIPING FOR 1000-DEG. STEAM FROM SUPERHEATER TO TURBINE

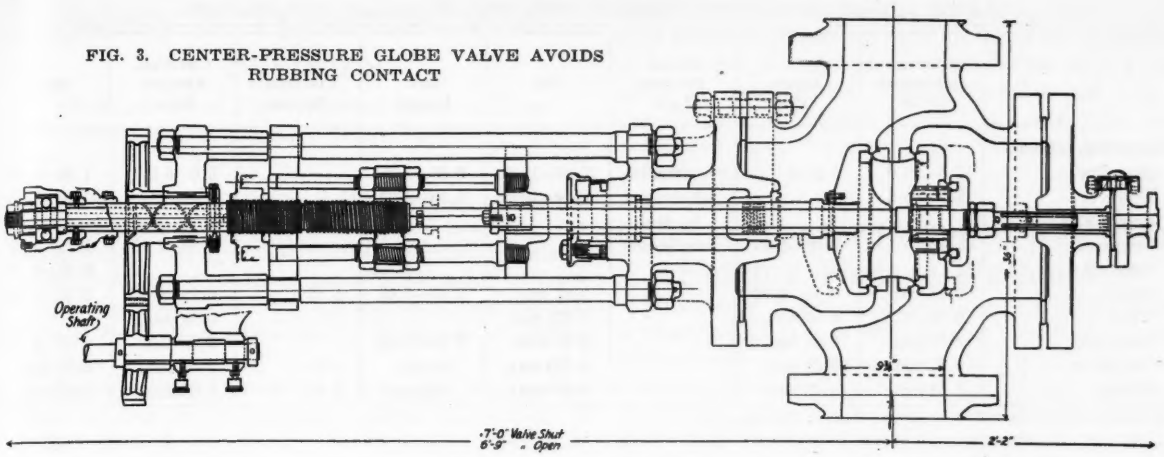
Effects of 1000 Degrees

Since 1929 a small superheater has been operated to study the properties and effects of 1000-deg. steam. Such steam is hot. It scorches canvas insulation jackets and clothing. Leaks are invisible and must be detected by means of rags on the ends of sticks, which are set on fire by the escaping steam. Bolts stretch so that it seems impossible to keep the ordinary flange joint tight more than a short time. Experience leads, however, to

*By courtesy of Heating, Piping and Air Conditioning.

**Engineer assistant to the general manager, Detroit Edison Co.

FIG. 3. CENTER-PRESSURE GLOBE VALVE AVOIDS RUBBING CONTACT



the belief that the piping system can be made reasonably reliable.

Plant Details

To raise 700-deg. steam to 1000 deg. an oil-fired superheater will be used, supplying steam to the turbine throttle at 365 lb. gage. The turbine is already operating at 700 deg. What it will do at 1000 deg. remains to be discovered, but the calculated heat rate is 10,480 B.t.u. per kw-hr. as compared with 11,145 B.t.u. for the best point of the 50,000-kw. units using 700-deg. steam. This is a gain of 6 per cent with a unit of 1/5 the capacity.

From the superheater, steam passes through a 10-in. special valve, Fig. 3, with reducers to 8-in. piping arranged to care for expansion as shown in Fig. 2. Ten-inch pipe was first considered and the valve ordered on that basis but, as it would be difficult to obtain seamless pipe in that size, the 8-in. pipe was adopted. The U-shaped run was adopted to take care of expansion. For the chromium-nickel steel used, the expansion at 1000 deg. F. per 100 ft. of pipe will be 11.3 in. The expansion provision must consider allowable thrust on the turbine throttle flange, fiber stress in the pipe wall and bending movements at the flange joints. Investigation showed that the first and last forces would be well within allowable values so that stress in the pipe wall would be the limiting factor. Considering bursting, expansion and other probable stresses, the maximum fiber stress worked out to 6240 lb. per sq. in. at the point indicated in the plan view of Fig. 2.

Although some stresses are gradually relieved as creep takes place, this requires time, hence the stress imposed immediately after the pipe reaches operating temperature must be taken care of in design.

Joints

As difficulty was experienced with flange joints in the preliminary experiment, probably due to bolts being stressed beyond the yield point by difference in expansion of bolts and flanges, so that gasket pressure was relieved, several kinds of joints are used in this piping system to try them out. The various types are shown in Fig. 4. In A-1 and A-3 the pipe ends are welded, but because of uncertainty as to the performance of welds at 1000 deg., these are backed up by bolted flanges. Welds will be as strong as the pipe and undoubtedly will be satisfactory but, in case of failure, bolts and flanges will hold the pipe ends together, although the bolts will doubtless stretch until stress in them is low and will so remain.

In A-1, loose flanges bear against rings which are screwed onto the pipe, then welded. This construction was used because of the difficulty of forming the ends of chromium-nickel pipe into flanged shape. Rings are the same material as the pipe but flanges are low-alloy steel.

In A-3, used for joints near the superheater which will not need to be disconnected, flanges are cast to the pipe, the pipe ends welded and flanges bolted to back up the weld.

As the welded joint is not readily made with valves and fittings of commercial design nor readily broken and remade, type B was developed for such uses and

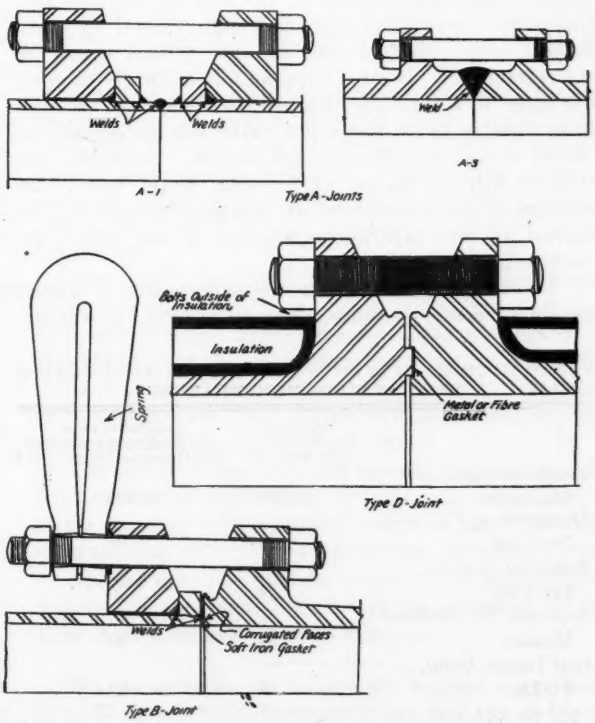


FIG. 4. VARIOUS SPECIAL PIPE JOINTS ARE USED, TO DETERMINE THEIR FITNESS

TABLE I. COMPOSITION OF MATERIALS USED FOR 1000-DEGREE INSTALLATION

	Cast Fittings at Superheater Outlet	Relief Valve	Center Pressure Valve	Pipe	Lose Flanges	Cast Steel Reducer	Cast Steel Reducing Elbow	Bolts
Composition, per cent:								
Chromium	17.0—20.0	5.0—6.0	Composition not divulged by steel manufacturer	17.00—19.00	0.90—1.25		5.0—6.0	1.20—1.40
Nickel	8.0—10.0			8.00—10.50	1.50—2.00			
Molybdenum						0.50		
Tungsten		0.80—1.25					0.80—1.25	1.75—2.25
Vanadium								0.20—0.25
Carbon	0.25 max.	0.15—0.22		0.07 max.	0.35—0.45	0.25	0.15—0.22	0.45—0.50
Silicon	0.25—0.75	0.50 max.		0.025 max.			0.50 max.	
Manganese	0.65 max.	0.50 max.		0.50 max.	0.30—0.60		0.50 max.	0.20—0.35
Phosphorus	0.03 max.	0.05 max.		0.025 max.	.04 max.	0.05	0.05 max.	0.05 max.
Sulphur	0.03 max.	0.05 max.		0.025 max.	.045 max.	0.05	0.05 max.	0.05 max.

[a] Used in the valve body. Disc and seat of stainless steel.

used at the center-pressure valve as indicated in Fig. 2, plan view. The hairpin spring, of high-grade spring steel, is designed to compensate for stretch of the bolts so that stretch of 0.1 in. will decrease gasket pressure only 20 per cent. As they will be uncovered, their temperature will be not over 500 deg. and elastic properties will not be affected.

Type D, an English design, is used at the turbine throttle, with large bolt circle and bolts left uncovered so as to avoid their reaching high temperature.

Some difficulties are, naturally, expected with these joints, which are not necessarily the final designs for 1000-deg. piping.

Superheat Regulation

To maintain flow of steam through the superheater, in case of quick stop of the turbine, a solenoid-operated relief valve, interlocked with the turbine throttle is connected to the smaller outlet of the 10-8 in. reducing tee. Unless this were done, the superheater would be overheated, even with fuel shut off, due to heat stored in the refractories. Besides tripping automatically to open discharge to a vent line through the roof when the turbine throttle trips, the relief valve can be opened or closed by a manually-operated switch. Normally, the turbine will be started on 700-deg. steam before the burners of the superheater are lighted; burners will be turned off and superheater allowed to cool before the turbine is shut down.

To control the flow from the superheater, a special design of center-pressure globe valve, Fig. 3, was devised, with two discs seating simultaneously from opposite directions. This avoids any rubbing contact and is expected to give tight closure.

Dimensions of flanges and fittings will, in general be those for the 900-lb. W.S.P. American Standard, except that the center-pressure valve has dimensions for the 600-lb. standard, turbine throttle has extra large bolt circle and superheater outlet fittings have extra thick flanges.

Insulation for the piping will be 4½ in. thick, the inner 3 in. heat resisting, probably with a large percentage of diatomaceous earth, the outer 1½ in. of 85-per cent magnesia. There is no particular difficulty in the insulation but material next the pipe wall may show some deterioration after a time.

TABLE II. CHANGES IN PHYSICAL PROPERTIES OF TUBING USED AT HIGH TEMPERATURE

	Similar Material As Received	Specimens from Piping Examined After 6400 Hours at 700 to 1100 F
Tensile strength, Lb./sq. in.	91,600	95,100
Elongation in 8", Per Cent	53	35
Reduction of area, Per Cent	59	36
Rockwell "B" hardness Number	76	80
Izod Impact Value, Ft.-Lb.	97	92

[a] Tests made at room temperature.

Kinds of Material Used

For the pipe wall, material must take fairly high stress with little permanent distortion so that a thin-walled pipe can be used to flex with the expansion. Material selected is chromium-nickel steel of composition shown in Table I. This has been used somewhat in oil and chemical plants, apparently satisfactorily unless exposed to chemical attack. It hardens some under strain and with high temperature changes its structure slightly. The changes after 6400 hr. service in experimental use are shown in Table II. Carbon must be kept low and no copper allowed to come into contact. As to creep-resistance, a similar steel showed that, at 1000 deg., 15,000 lb. stress was required to cause one per cent growth in 100,000 hr. as against 3300 lb. for ordinary 0.45 carbon steel.

While for Delray with its moderate pressure, low stresses might be used in fittings by using heavy sections, this might not be practicable for future high-pressure and high-temperature plants. Low-alloy steels have been chosen for the most part but such as to withstand reasonably high stress with small creep. To get resistance to oxidation, it may be found necessary to line with stainless steel or to coat them in some manner. Analyses of the steels selected for various uses are given in Table I. For the center-pressure valve, the body will be of a chromium-molybdenum alloy and the seat and discs of a metal chosen specially for high-temperature service.

EXCEPT UNDER special conditions, electrical energy is still too expensive to use as a source of heat.

Safety in Pulverized Fuel Systems

REGULATIONS OF THE NATIONAL BOARD OF FIRE UNDERWRITERS CONTAIN MUCH MATERIAL OF VALUE TO ENGINEERS

REGULATIONS for the installation of pulverized fuel systems, issued by the National Board of Fire Underwriters and approved by the American Standards Association, are covered in bulletin Z12-a-1930. These regulations are designed for application to new installations or for making alterations or extensions to existing plants.

Pulverized fuel systems are divided into three classes, those in which the power plant engineer is interested in being: Class A, or indirect, in which the fuel is intimately mixed with air at the point or points where used and involving storage bins at points of consumption and the Unit System in which the fuel is pulverized at or near the point or points of use and delivered directly from the pulverizer into the furnace by means of a fan or blower.

Buildings housing fuel pulverizing equipment must be constructed of incombustible material. Piping requirements, building construction and glass area depend upon the size of the equipment, the arrangement of the room and whether the pulverizing equipment is in the same room in which the fuel is burned or in a separate compartment separated from the rest of the building by masonry walls and floors. Details of the ventilation, dust collecting equipment, pulverizer, magnetic separator, electrical connections, dust collectors, vents and bins and dryers are covered.

Under these regulations, no pulverizer can be connected to supply more than one furnace at a time, but this shall not be construed to prevent the installation of spare pulverizers which may be connected to any one of several furnaces if the regular pulverizer is disconnected by removing a section of the discharge pipe between the pulverizer and the furnace. Piping from the mill to the burners must be arranged so that when a mill is in use all burners which that mill can supply shall be in operation. Two discharge pipes from separate mills shall not be connected to the same burner nozzle.

STORAGE OF COAL

Storage of pulverized or dried crushed coal is of pronounced importance because of spontaneous combustion. In order to safeguard against fires, the following recommendations have been made.

Temp. of coal entering mills	Max. time for storing pulv. or dried crushed coal
1. Semi-Anthracite Coal	
200 deg. F.	12 hr.
175 deg. F.	16 hr.
150 deg. F.	24 hr.
140 deg. F.	36 hr.
130 deg. F.	One week
2. Bituminous Coal having less than 2 per cent Sulphur	
180 deg. F.	12 hr.
150 deg. F.	18 hr.
130 deg. F.	24 hr.
120 deg. F.	One week
3. Lignite, Sub-Bituminous and High Sulphur Coal	
150 deg. F.	12 hr.
130 deg. F.	16 hr.
120 deg. F.	24 hr.
110 deg. F.	36 hr.
100 deg. F.	One week

Because of their higher inherent moisture, the last group coals will drop in temperature in milling and will go to the pulverized coal storage at considerably lower temperatures, provided the milling system is properly vented to release the moisture given off in grinding. If no water is evaporated, there will be only a small drop in temperature. Whenever pulverized coal or crushed coal are stored in the plant, a regular daily inspection should be made to see that there are no fires or overheating.

Contract Let for Design of New Steam Heating Plant at Washington

DWIGHT P. ROBINSON, president of United Engineers & Constructors, Inc., of Philadelphia, recently announced the execution of a contract with the United States Government, Treasury Department, for the preparation of engineering plans for the new central heating plant and steam and electrical distribution systems to be built in Washington, D. C., at a cost of $5,749,000.

This new central steam heating plant—which will be one of the largest in the United States—has been under consideration for a period of years. The decision to build it at this time has been reached because of the additional heating requirements of the new government buildings recently completed and now under construction or contemplated in the future, in the district bounded by Pennsylvania Avenue, Maryland Avenue, and 15th street.

In this area the new plant will supply heat to 26 government buildings, including the Smithsonian Institution, Bureau of Engraving and Printing, Veterans Bureau, Department of Agriculture, old National Museum, new National Museum, Washington Monument, Commerce, Internal Revenue, Treasury and other buildings.

In an average year these buildings, including those planned for the future, will consume 1,500,000,000 lb. of steam. The new heating plant will provide for 75 per cent of that capacity and will be designed to permit of future extensions.

Steam will be distributed to the buildings through an underground system of pipes varying in diameter from 3 in. to 18 in., with an aggregate length of approximately 5 mi. In connection with the heating plant, an electrical substation will be built to distribute electric power, all of which is to be purchased from the Potomac Edison Co.

The public buildings which will be supplied with steam and electric light and power in the initial installation will consume approximately 34,000,000 kw-hr. of electric current in an average year with a maximum demand on the electrical distribution system of approximately 18,000 kw. The future extensions will increase these demands by about 35 per cent.

The design of the plant will embody the most modern features in the combustion of fuels and production of steam, together with electrical design to provide service of maximum reliability at minimum investment cost.

Special attention will be given to the architectural features of the plant, which will be approved by the Fine Arts Commission of Washington.

WATER RATES on noncondensing engines range from 20 to 60 lb. per brake horsepower but may run as low as 10 lb. on condensing engines.

What Method Should be Used to Give a Fair

Comparison of Steam Station Performance

By C. C. Baltzly
Operating Engineer
Philadelphia Electric Co.

With the diversity of steam pressures, temperatures and operating cycles has come the need for a fair method of comparing the performance steam stations. In an effort to establish an acceptable method for this purpose, Professor A. G. Christie of Johns Hopkins University prepared an article, which was published in the June 15, 1930, issue of Power Plant Engineering, describing with formulas and diagrams a method he had conceived. Discussions of Professor Christie's method by E. B. Ripley and H. L. H. Smith were published in the August 15, 1930, issue and another by Paul H. Jeynes in the February 1, 1931, issue. This discussion by Mr. Baltzly presents additional data on the subject and describes how the formulas developed are used by the Philadelphia Electric Co.

PROFESSOR CHRISTIE'S attempt to obtain a more satisfactory method of comparison for various stations is a long step forward from the old method of stating performance in terms of B.t.u. per kilowatt-hour and certainly deserves the consideration of all central station men. There are, however, several items affecting station performance which have not been taken care of in his method. Professor Christie frankly states this in his article and this discussion is not so much a criticism of his plan as an addendum to it.

Among the more outstanding of these items which have not been taken account of are: The effect of the ratio between average kilowatt load and the kilowatt peak prepared for; the known fact that the incremental steam input to turbo-generators increases when the overload valve comes into play; the reduction in boiler efficiency at higher loads; and the effect of circulating water injection temperature. E. B. Ripley, H. L. H. Smith and Paul Jeynes in discussions of Professor Christie's plan have suggested the desirability of providing for a consideration of some of these items and have presented some thoughts on the subject. There is no doubt that if a simple formula for stating plant performance could be developed which would take these various items into account without too much unavailable and expensive data being required, that such a formula would be much more desirable primarily because of the additional information that it would contain for comparison of stations and also because of its greater accuracy.

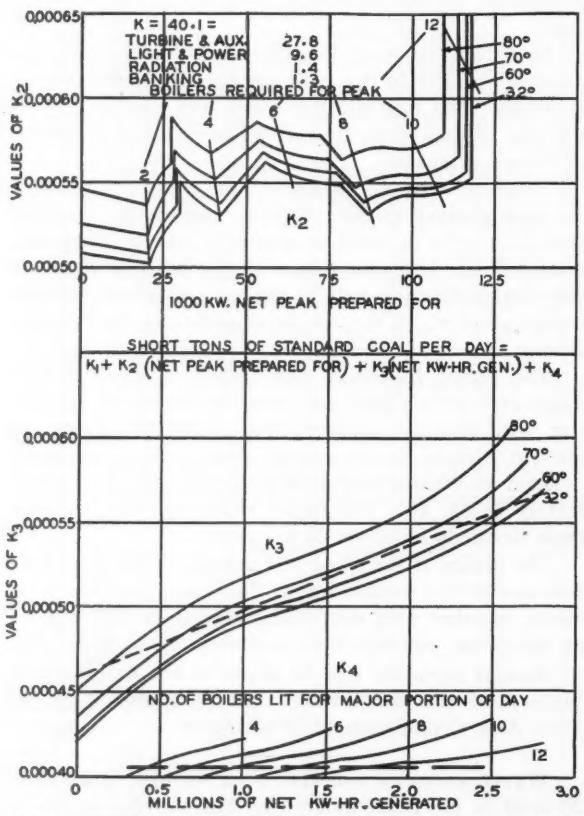

K = 40·1 =
TURBINE & AUX. 27.8
LIGHT & POWER 9.6
RADIATION 1.4
BANKING 1.3
BOILERS REQUIRED FOR PEAK
VALUES OF K2
K2
1000 KW. NET PEAK PREPARED FOR
SHORT TONS OF STANDARD COAL PER DAY =
K1 + K2 (NET PEAK PREPARED FOR) + K3 (NET KW-HR. GEN.) + K4
VALUES OF K3
K3
K4
NO. OF BOILERS LIT FOR MAJOR PORTION OF DAY
MILLIONS OF NET KW-HR. GENERATED

FIG. 1. RESULTS OF TESTS OF A PHILADELPHIA ELECTRIC CO. PLANT WORKED UP INTO "BOGIE" CURVES

Bogie Curves Prepared from Tests

Philadelphia Electric Co. has used for a number of years a set of curves prepared for each station which have been called bogie curves. These curves are prepared from tests on all the plant equipment from the main units and boilers down to the small auxiliaries and form the standard of performance or goal for the operators of each station. The determination of these curves for the sole purpose of providing the information required in the determination of this formula for stating plant performance is obviously not warranted, but the use which can be made of them in checking station performances, allocating load between stations, determining the value of interchange power between interconnected systems and so forth, more than justifies the expense involved in obtaining them. From these bogie curves have been developed a second set of curves for each station from which various factors may be obtained which when multiplied by the proper quantities and the products combined will give the bogie coal required for any day's generation. It is from these curves as a basis that the formula similar to Professor Christie's formula but extended to include other quantities has been developed. Figure 1 is a reproduction of a set of

these curves for one of the Philadelphia Electric Co. stations.

It will be noted that the daily coal is divided into four portions. The first of these, K_1, is a constant and is a measure of the no load station use, that is, for one unit idling on the line with the necessary auxiliary equipment. The second factor, K_2, is a factor which when multiplied by the kilowatt station peak prepared for will give the coal required for standby but not including any generation. The third factor, K_3, is a factor which when multiplied by the station net output will give the coal required for this output, under the load factor regularly expected on the station for the output considered, with all the boilers in the plant in operation. This quantity of coal is over and above the coal required for standby and for no load and includes the coal required for the operation of the various auxiliaries for the output under consideration. The fourth factor, K_4, gives the additional coal required by using less boilers than are installed in the plant, thus accounting for the reduction in boiler efficiency at increased ratings when fewer boilers are in use.

These curves are designed for daily operation, consequently they take into account all the variations that may occur from day to day. For the purpose of this study it would be virtually impossible to consider all of these variations, hence average daily conditions have been considered as indicated by the dotted lines. The error so introduced is probably within one per cent plus or minus except at extremely low loads. Under these conditions, K_4, becomes a constant number of tons of coal per day due to the fact that the number of boilers on the line is normally reduced as the output of the station is reduced. Hence K_1, and K_4, may be combined to form a new constant, Peak Preparation Factor, tons of coal per day, D_1. K_2, for average plant conditions, becomes a constant quantity, D_2, which when multiplied by the station peak prepared for (P.P.F.) gives the coal required for standby. The peak a plant is prepared to carry is determined by the number of boilers prepared to carry load. If the banking or no load coal for the boilers is known and the equivalent electrical capacity of the boilers is known the constant, D_2, may be obtained by dividing this first quantity by the second. The K_3 factor is divided into two portions, the first being the value of the dotted K_3 line at zero output, called D_3, and the second, being the slope of the dotted K_3 line, called D_4. The factor, D_3, multiplied by kw-hr. generated plus the factor D_4 multiplied by the (kw-hr. generated)^2 gives the coal required for genereation. The slope of these K_3 lines is occasioned by the fact that the boiler efficiency decreases as the load on the plant increases because the boilers must be run at a higher average rating, and by the fact that the water rates of the main units increase when it is necessary to operate on loads above the point where the overload valve opens.

Development of Coal Requirement Formula

The following formula may then be developed to express the coal required for the generation of a given number of kw-hr. under average daily conditions:

$$\text{Coal Burned} = D_1 + D_2\ (\text{Kw.-PPF.}) + D_3\ (\text{Kw-hr. gen.}) + D_4\ (\text{Kw-hr. gen.})^2$$

All bogie coal is figured on the basis of 13,800 B.t.u. per pound as fired so that the above formula may be expressed in such a manner as to give the B.t.u. input. This divided by the net kw-hr. generated will give a formula for B.t.u. rate under various loads and peaks prepared for at one circulating water temperature. This formula for B.t.u. rate may be simplified as shown in the sample calculations attached so that it will involve four constants, the capacity factor, and the ratio of average load to average peak prepared for, herein called the peak prepared for factor.

The general form for this resulting equation is:

$$\text{B.t.u. per net kw-hr.} = \frac{C_1}{\text{Cap. Factor}} + \frac{C_2}{\text{PPF. Factor}} + C_3 + C_4\ (\text{Cap. Factor})$$

As given here, the formula would normally be developed as it has been in the sample calculations, for the average yearly injection water temperature. A correction factor may be developed, however, for making this formula applicable to any other circulating water temperature. This correction factor will be applicable to the C_2, C_3, and C_4 constants and is obtained from a cross plot of the K_3 lines of Fig. 1 for various circulating water temperatures. A formula in the following form will result for this correction factor:

$$A = B + M\ (t - 32)^2$$

wherein

A = Correction factor

B = Correction factor at 32 deg. F. circulating water temperature

M = Coefficient of $\overline{\text{temperature}}^2$ to obtain variations in the factor.

Determination of the values of B and M are shown in the accompanying sample calculations.

For use in comparing various generating stations, then, the complete formula is in the following form:

$$\text{B.t.u. per net kw-hr.} = \frac{C_1}{\text{Cap. Factor}} + A\left[\frac{C^2}{\text{PPF. Factor}} + C_3 + C_4\ (\text{Cap. Factor})\right]$$

Significance of Constants

Quantities of which the C_1, C_2, C_3 and C_4 constants are indices, together with their definition and the factors entering into their make-up are outlined in the following paragraphs:

The first of these constants, C_1, will provide an index to the no load losses, and it may be defined as the B.t.u. no load input per hour per unit of station capacity. The following factors are included in this portion of the formula:

1—One main unit no load input, including auxiliaries.

2—No-load light and power.

3—Loss due to radiation from piping.

4—A prorated portion of the first boiler banking coal.

5—The average daily adjustment coal.

6—House heating.

The second of these constants, C_2, will provide an index to the non-productive input required for peak

standby, and it may be defined as the non-productive B.t.u. input per hour per unit of station peak prepared for. It includes:

1—The banking or no load input to the boilers required for peak standby.

The third of these constants, C_3, will provide an index to the performance of the heat cycle as provided in the plant. It may be defined as the increment B.t.u. per kw-hr. input for the first kw. load on the plant. It includes:

1—The increment heat per kw-hr. required by the main unit, corrected for boiler efficiency, for the first kw. load.

2—The increment increase in input to the auxiliaries for the first kw. load, or

3—The increment reduction in the losses from the auxiliaries, as in the case where the exhaust from the steam auxiliaries goes to the free exhaust stack below a certain load. Such a loss will be reduced as the load increases from zero to this load.

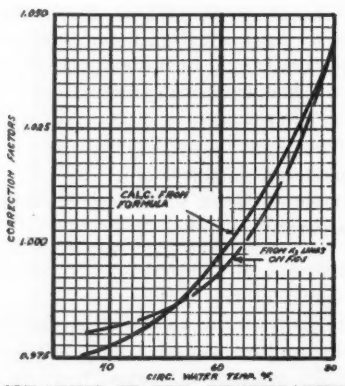


FIG. 2. CIRCULATING WATER TEMPERATURE CORRECTION FACTOR CURVE

The fourth of these constants, C_4, will provide an index to the rate at which the boiler and turbine efficiencies reduce with increasing loads. It may be defined as the B.t.u. per kw-hr. increase in the C_3 constant from zero to 100 per cent capacity factor. It includes the following:

1—Additional input per kw-hr. required, due to decreasing boiler efficiency with increasing load.

2—Increased main unit input per kw-hr. when operating at loads where the overload valve is in use.

Magnitude of Constants in Dissimilar Stations

It is interesting to note the magnitudes of the various constants in this formula for dissimilar stations, and to analyze the reasons for the differences. The following is a tabulation for three Philadelphia Electric Co. plants:

	C_1	C_2	C_3	C_4
Station A.....	605	483	10,830	1,350
Station B.....	294	637	13,250	2,510
Station C.....1,220		1,265	12,370	6,880

Station A is a modern 400-lb. plant using a regenerative cycle. The boilers are stoker fired and all equipped with preheaters. The auxiliaries are electric driven. Two units of 60,000 kw. each are installed.

Station B is a somewhat older 250-lb. plant. Boilers are stoker fired without preheaters and are each good for about 35 per cent less electrical capacity than the Richmond boilers. Some of the auxiliaries are steam driven. There are six units of 30,000 kw. each.

Station C is a 225-lb. plant about 15 yr. old and is now used for peak and reserve. The boilers are small, stoker fired, with no preheat. Most of the auxiliaries are steam driven. There are two units, one of 30,000 and one of 35,000 kw.

C_1 is the B.t.u. no load input per hour per unit of station capacity. If the various C_1 constants are multiplied by the respective station capacities it will appear that the no-load station input is lower for Station B than for Station A or Station C. The fact that station C is high is explained by its older design involving less efficient boilers and units and the consequent higher no-load loss. Station A is higher than Station B because the pressure is higher, thus requiring more no-load auxiliary power, and the units are larger, thus requiring more no-load input. As the capacity installed in a plant is increased the constant C_1 will decrease in almost the same proportion, provided the units remain the same size. The only factor preventing this ratio from holding exactly is the increase in the amount of station unaccounted for losses with more equipment.

C_2 is the nonproductive B.t.u. input per hour per unit of station peak prepared for. The amount of peak prepared for determines the number of boilers under fire and ready to make steam. The magnitude of C_2 therefore depends on the amount of no-load coal required by the boilers and on the equivalent electrical capacity of the boilers. At Station A the no-load coal for the boilers is the same as at Station B, but the boilers are good for 50 per cent more electrical capacity. At Station C the no-load boiler coal is less but the equivalent electrical capacity is much smaller, thus accounting for the large C_2 constant.

C_3 is the increment B.t.u. per kw-hr. rate of the plant for the first kw. load. This constant therefore indicates the type of heat cycle used in the plant. This factor is also affected by the characteristics of the auxiliary equipment at zero plant load, particularly in plants where the loss increases as the load on the plant decreases, as in cases where steam driven auxiliaries are installed, which exhaust to the free exhaust stack below certain plant loads. C_3 is lower for Station A than the other plants due to its regenerative cycle. It is lower for Station C than for Station B, due to the fact that the steam auxiliaries send considerable heat up the free exhaust stack at zero plant load.

C_4 is the increase of the C_3 constant with capacity factor. The magnitude of this factor therefore will be principally determined by the amount the boiler efficiency decreases at high loads and by design of the main units for overload. The effect of improvements in boiler design, particularly, may be noted in the C_4 constants as given for Stations C, B, and A.

Checking Accuracy of Formula

In order to check the accuracy of this formula, Fig. 3 was drawn up for one Philadelphia Electric Co.'s plant. The abscissa in the figure is the B.t.u. rate as calculated by the formula and the ordinate is the B.t.u. rate as calculated from a summation of daily bogie coal burned. Each point in the figure is for a month's

operation. If the two methods of calculation had resulted in exactly the same values, all of the points would have fallen on the 45 deg. line drawn in solid on the figure. Any points falling within the two dotted lines show a check within ± 1 per cent. The range of capacity factors for the various points plotted is from 0.21 to 0.56. The range of circulating water temperatures is from 36 to 80 deg. F.

There is one fact that should be noted in connection with this check, namely, that the formula as developed is for the average day, and that it, therefore, must be adjusted for comparison with monthly performance. This is due to the fact that the sum of each day's burn for the month is usually greater than the burn for the average day times the number of days. The reason for this lies in the fact that the duration curve for the month is not the same shape as the duration curve for

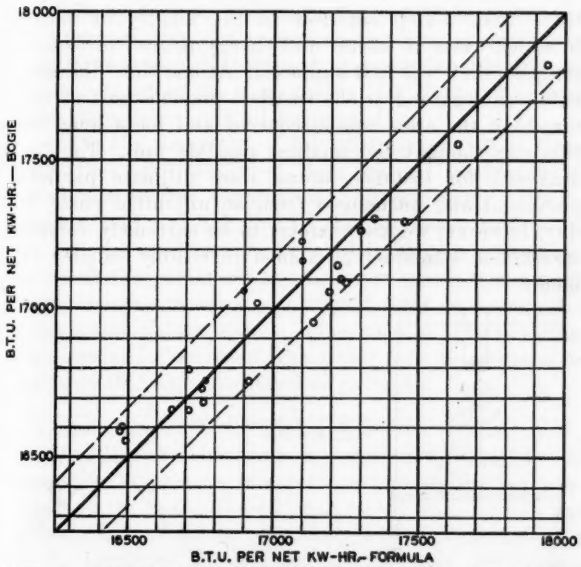


FIG. 3. COMPARISON BETWEEN FORMULA AND BOGIE B.T.U. RATE

the single day. The difference between the two methods of calculation is normally in the order of from one to two per cent.

An advantage of the Philadelphia Electric Co. formula lies in the fact that it can be accurately determined for the whole range of possible plant operating conditions even though these conditions are not met in actual operation. In the case of the Philadelphia Electric Co.'s stations a wide range of actual capacity factors is available due to the effort of the Conowingo operating some of the time on base load and at other times on peak load. Such favorable conditions for obtaining the Christie formula are not usually available, however, and it may be necessary to determine the Christie formula from a set of points within a narrow range of capacity factors. In such a case it is difficult to determine accurately the slope of the Parson line for Christie's formula.

Also, the Christie formula, being based on actual performance, may be subjected to incorrect operating practice, hence may not indicate the actual possibilities of the plant. The P. E. Co. formula, on the other hand, being based on tests of plant equipment under the best operating conditions, does not have this disadvantage.

Calculations of Station B.T.U. Rate Formula

From dotted lines of Fig. 1.

$D_1 = 40.1 + 5.9 = 46$ tons per day.

$D_2 = 0.00056$ tons per day per kw. peak prepared for.

$D_3 = 0.00046$ tons per day per net kw-hr. generated.

$D_4 = 38 \times (10)^{-12}$ tons per day per (net kw-hr. generated)^2

Therefore—

Tons of coal per day $= 46 + 0.00056$ (kw-PPF.) $+ 0.00046$ (kw-hr. gen.) $+ 38 \times (10)^{-12}$ (kw-hr. generated)^2

B.t.u. per ton coal $= 13{,}800 \times 2{,}000 = 27.6 \times 10^6$

Daily B.t.u. input $= 27.6 \times 10^6\ [46 + 0.00056$ (kw-PPF.) $+ 0.00046$ (kw-hr. gen.) $+ 38 \times (10)^{-12}$ (kw-hr. gen.)^2

$= 1{,}270 \times 10^6 + 15{,}500$ (kw-PPF.) $+ 12{,}710$ (kw-hr. gen.) $+ 1{,}049 \times (10)^{-6}$ (kw-hr. gen.)^2

Let kw-hr.$_a$ = daily net kw-hr. generated.

Then—

$$\frac{\text{B.t.u. Input}}{\text{Net kw-hr.}} = \frac{1{,}270 \times 10}{\text{kw-hr.}_a} + \frac{15{,}500}{\text{kw-hr.}_a}\ (\text{kw-PPF.}) + 12{,}710 + 1{,}049 \times (10)^{-6}\ (\text{kw-hr.}_a)$$

Kw-hr.$_a$ = 24 × Avg. kw. load

$$\frac{\text{B.t.u.}}{\text{kw-hr.}} = \frac{53 \times 10^6}{\text{Avg. kw. load}} + \frac{647\ (\text{kw-PPF.})}{\text{Avg. kw. load}} + 12{,}710 + 0.0252\ (\text{Avg. kw. load})$$

$$= \frac{\dfrac{53 \times 10^6}{\text{Sta. kw. cap.}}}{\dfrac{\text{Avg. kw. load}}{\text{Sta. kw. cap.}}} + \frac{\dfrac{647\ (\text{kw-PPF.})}{\text{kw-PPF.}}}{\dfrac{\text{Avg. kw. load}}{\text{Sta. kw. cap.}}} + 12{,}710$$

$$+ 0.0252 \left[\text{Sta. kw. cap.} \left(\frac{\text{Avg. kw. load}}{\text{Sta. kw. cap.}}\right)\right]$$

$$\frac{\text{Avg. kw. load}}{\text{Sta. kw. cap.}} = \text{Capacity Factor}$$

$$\frac{\text{Avg. kw. load}}{\text{kw-PPF.}} = \text{Peak Prepared for Factor}$$

Station Capacity = 126,000 kw.

Therefore for this station—

$$\text{B.t.u. per kw-hr.} = \frac{421}{\text{Cap. Factor}} + \frac{647}{\text{PPF. Factor}} + 12{,}710 + 3{,}170\ (\text{Cap. Factor})$$

Calculation of Circulating Water Temperature Correction to B.T.U. Rate Formula

A cross plot of the K_3 lines of Fig. 1 is made as shown in Fig. 2, giving the relationship between the circulating water temperature and the ratio of K_3 at a selected load for the actual water temperature to the value of K_3 for the temperature as used in the formula, at that same load. The circulating water temperature used in these calculations has been 64 deg. F.

General formula for the curve, Fig. 2, is—

$$A = B + M\ (t - 32)^2$$

at 32° F. $A = 0.98$

at 80° F. $A = 1.047$

at 32° F., $M\ (t - 32)^2 = 0$

Therefore at 80° F., $B = 0.98$

$M\ (t - 32°\text{ F.})^2 = 1.047 - 0.980 = 0.067$

and so $t - 32 = 80 - 32 = 48$

$M\ (48)^2 = 0.067$

$$M = \frac{0.067}{(48)^2} = \frac{0.291}{10{,}000}$$

Resulting in the following formula—

$$A = 0.98 + 0.291 \left(\frac{t - 32}{100}\right)^2$$

Say

$$A = 0.975 + 0.3 \left(\frac{t - 32}{100}\right)^2$$

Thermometer wells should be constructed so that they have the smallest possible metallic section consistent with the necessary strength next to the wall of the pipe so that the amount of heat lost or gained by conduction will be as small as possible.

ELECTRICITY—
What it is *and* How it Acts

Part LI

The wave theory of the electron and its experimental verification. ¶ A discussion of de Broglie's theory and the experiments of Davisson and Germer and G. P. Thomson. Determination of the wave length of the electron.

By A. W. Kramer

FROM THE PRECEDING discussion of the origin of the sun's heat, it may seem that we have neglected to answer the question, "What are the electrons and protons themselves?" This not quite true, however, for in accounting for the sun's heat on the basis of the annihilation of matter by the complete neutralization of protons and electrons, the question has answered itself. *Electrons and protons are energy.*

This, of course, is nothing more than what we have implied throughout this entire series of articles and since we do not know what energy is, the information adds little to our knowledge—indeed, it is merely the substitution of one unknown term for another. And here the matter must rest, for until we know more about the exact nature of energy we can expect to know little more about the absolute nature of the electron and the proton.

This condition of affairs need not be discouraging, however, for it does not carry with it the implication that it limits us from extending our knowledge of electrons and protons beyond what is known today. Indeed, within the past few years certain facts have been discovered which have given us an entirely new conception of these small but important entities.

Until quite recently, the only properties that could be attributed to the electron with certainty was that its mass was 9×10^{-28} grams and its charge 4.774×10^{-10} electrostatic units. A size could be calculated on the assumption that the electron followed the ordinary laws of a charged metal sphere, but the value found 3.7×10^{-13} cm. was neither confirmed nor contradicted by experimental evidence. These properties, however, told us nothing regarding the structure of the electron—whether it was merely the point source we assumed it to be or whether, like the atom, it was built up of smaller parts, sub-electrons. The mere fact that no evidence of such sub-electrons had ever been discovered was no valid reason for concluding that the electron possessed no structure beyond being "just a little red or gray ball" as Eddington put it. In mathematics, it is true, the electron was considered to be a point charge but there is no evidence to show that the convenience of mathematicians is a dominent factor in the scheme of the universe.

As a matter of fact, there were several reasons for suspecting the electron to possess a more complex structure than there was evidence of. In the first place, there were many instances in the history of science in which units of matter and energy proved to be more complex than was first supposed. At one time, the molecule was regarded as the smallest possible unit of matter; then the atom was discovered and for a long time this was thought the smallest possible unit. To Clerk Maxwell, for instance, atoms were ultimate particles, persistent and unchanged from an unlimited past. Today, however, we know atoms to be extremely complex structures, composed of almost incredibly smaller elements.

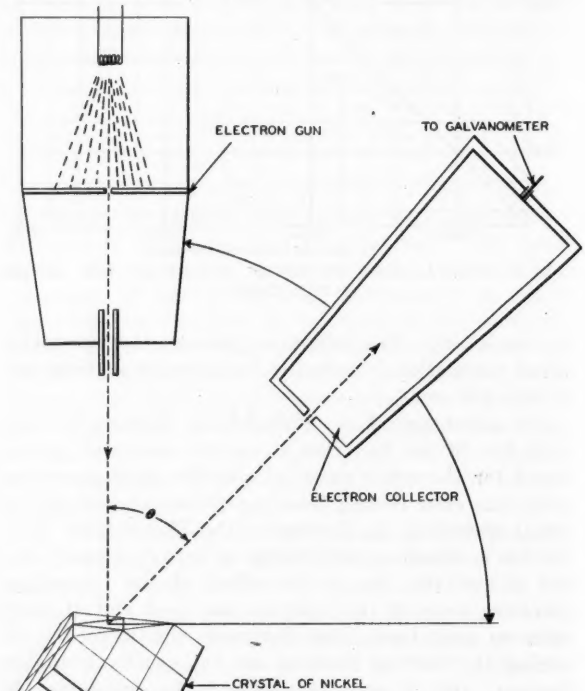


FIG. 1. METHOD OF ELECTRON DIFFRACTION USED BY DAVISSON AND GERMER

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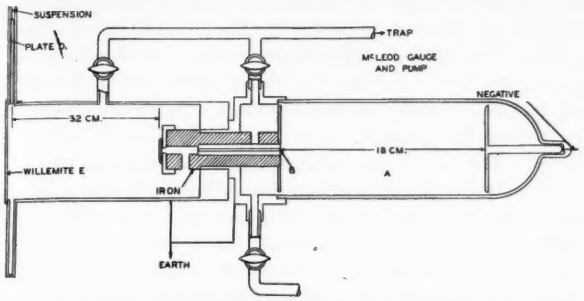


FIG. 2. APPARATUS USED BY G. P. THOMSON TO PROVE WAVE HYPOTHESIS OF THE ELECTRON

In the realm of radiation phenomena, also, it has been found necessary to alter our first conceptions. At the beginning of the century, the wave theory of light was one of the most firmly established facts in physics. Newton, it is true, originally thought light to be of a granular or corpuscular nature, but the phenomena of interference and diffraction had so overwhelmingly testified in favor of the wave theory that Newton's corpuscular hypothesis was all but forgotten.

With the discovery of the photoelectric effect, however, the wave theory of light seemed inadequate to provide a logical explanation and gradually evidence accumulated which indicated that the wave theory did not tell the whole story. To explain certain phenomena of which the photoelectric effect was one, it was considerably more convenient to regard light as being of a corpuscular nature than a wave nature. The quantum hypothesis of Planck, in fact, could only be accepted on the basis that light consisted of particles.

De Broglie's Theory

Thus two theories came into existence. When it was necessary to explain interference and diffraction phenomena, the wave theory was called into action but phenomena such as the photoelectric effect was explained on the quantum or corpuscular hypothesis. Obviously, it was somewhat illogical and in a certain sense, embarrassing to require the use of two entirely different theories to explain the same phenomena; but no satisfactory explanation was advanced until Louis de Broglie hit upon a brilliant synthesis of the two views. Briefly, his theory presented the idea that light, though actually corpuscular, was guided by waves. It implied that light was both a particle and a wave at the same time.[1]

De Broglie's theory, however, provided more than a logical explanation of "light" phenomena; as a matter of fact, it was quite general and applied to the electron as well as to light, although it was apparently contradictory to what was known about the motion of the electron. Indeed, if this theory were true, a stream of electrons would be refracted when entering a refracting medium just as light undergoes refraction in passing through a prism. No such effect, however, had ever been observed and to the orthodox mind the concept was quite astonishing. It might be conceivable that light could exhibit both the properties of a wave and a particle, but to extend that idea to the electron was something which we were not prepared to accept without definite proof.

Proof, however, was not long in coming. The idea was put to test and was soon confirmed by investigators both in America and in England. In this country, Davisson and Germer working at the Bell Telephone laboratories, and in England, Prof. G. P. Thomson, by different lines of attack proved the correctness of de Broglie's theory. It is rather a curious coincidence that the experiments proving the electron to possess the properties of a wave should be made by the son of the man (J. J. Thomson) who first proved the electron to be a particle.

Apparently, it is rather a mixed-up state of affairs. First, light is found to be both a particle and a wave and then before we can become reconciled to this idea, we find that the electron also partakes of both the propperties of a wave and a particle at the same time. Yet, when viewed in the proper attitude these concepts need not bewilder us; indeed, they simplify things considerably. For if it is true, and all evidence points to that fact, that both radiation and matter (electrons) are merely different states of energy, why should not both of these forms possess similar properties?

Thus we have a double picture of matter and radiation, both discrete or discontinuous in structure, both essentially some sort of waves, yet differing from one another in some respect not understood, but which may perhaps be best described by saying that matter waves are bound while energy waves are free.

Instead of being merely the point charge or the "little red ball" we thought the electron was, it is shown to be a complex structure, the nature of which possibly we have merely sensed. A moving electron, even a uniformly moving one, is always accompanied by a series of waves. These waves carry it along and determine the way it is to go much as a log is carried along on the crest of a water wave.

The proton also has been shown to possess the properties of a wave; this research being carried out by Dempster at the University of Chicago in 1929, as a consequence of predictions made by Schrodinger and Heisenburg and others. These theories of Heisenburg and Schrodinger it must be understood are all incorporated in the mathematical development of the quantum theory, and their experimental substantiation constitutes another link in the chain of events in which the highly abstract mathematics of the new physics and experience support one another.

Methods Used to Prove Wave Theory of the Electron

Before considering the further significance of these concepts, it will be of interest to know how the waves of the electron were determined. As stated above, the two groups of investigators employed different methods: Davisson and Germer refracted the electrons from the face of a crystal, while Thomson obtained refraction by passing a stream of electrons through thin sheets of metal foil.

The arrangement used by Davisson and Germer is shown in Fig. 1. A beam of electrons all of the same velocity is directed, normally, on the face of a nickel crystal, as shown, the face of incidence being one of the faces of the regular octahedron of the cubic system of nickel. If these electrons were merely particles as we thought them to be, we naturally would expect them to be scattered in all directions when striking the face of the crystal, just as a stream of water from a hose is scattered when directed against a brick wall. An en-

[1]See Part XXVIII, Sept. 15, 1929.

tirely different result was obtained, however; while there was some scattering, this scattering was much more pronounced in certain directions. The direction of these concentrations of scattering were easily determined by moving the ionization chamber or electron collector through an arc as shown. The source of the electrons in these experiments was a hot filament just as in a radio thermionic tube. These were accelerated by potentials which could be varied between 50 to 375v.

Results obtained in these experiments showed very clearly that there was a concentration of electrons scattered in the directions in which the associated wave is expected to present a maximum as a result of the agreement in phase between the waves diffracted by the different crystal centers.

Thus the phenomenon is exactly comparable with that of the Laue method for the diffraction of X-rays by means of crystals. The numerical values have, moreover, indicated clearly that a wave length of magnitude

$$\lambda = \frac{h}{m\,v}$$

must be attributed to the associated wave. In this formula λ is the wave length of the electron in cm.; h is

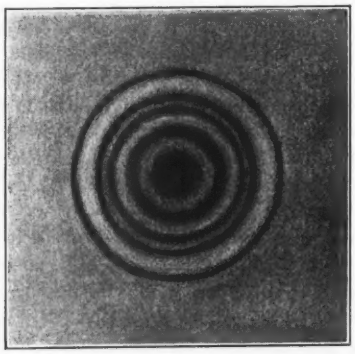


FIG. 3. RINGS PRODUCED WHEN A BEAM OF HIGH VELOCITY ELECTRONS IS PASSED THROUGH A THIN SHEET OF METAL

Planck's constant 6.58×10^{-27}; m is the mass of the electron and v its velocity. These experiments indicate that the waves of an electron moving with a speed equal to that of about 150 v., the wave length is about 10^{-8} cm. while for speeds due to an acceleration under 15,000 v. potential, the wave length is 10^{-9} cm.

G. P. Thomson's Experiments

Experiments of a similar kind have been brilliantly repeated by Professor G. P. Thomson in a different way. Thomson's method consisted of sending a beam of electrons through thin sheets of metal foil. Similar experiments had been made by Debeye and Sherrer using X-rays instead of electrons. When a narrow beam of X-rays is sent through a thin sheet of metal, the regular spacing of the molecules in the plate act like a diffraction grating and the beam will be diffracted to form a pattern of concentric rings which may be photographed by placing a photographic plate behind the metal foil. This much was known before Thomson conducted his experiments with electrons.

In Fig. 2, the apparatus used by Thomson is shown. It consists of a tube in which a stream of electrons generated in A is accelerated under potentials of from 18,000 to 64,000 v. and made to travel through a fine bore tube B (6 cm. long, 0.23 mm. bore) and a thin film of metal C, finally to impinge on a Willemite screen or photographic plate D.

As the electrons have far less penetrating power than X-rays, the metal film has to be made exceedingly thin, far thinner than the thinnest gold leaf. The gold films used were so thin that a lamp filament could be seen through them. These were further reduced in thickness by treatment with aqua regia while similar aluminum films, by caustic potash.

These plates, when they are obtained, are exceedingly valuable physical instruments, for, by their use in the apparatus just described, they enable us to test whether anything passing through them is a stream of particles or a train of waves.

Suppose that we have a thin pencil of rays and we wish to determine whether these are a swarm of particles all moving in the same direction or a train of waves. In either case, if the pencil falls directly on a photographic plate it will produce a sharply defined image. Instead of allowing the ray to play on the photographic plate directly, let us see what will be the effect on the image, of interposing the thin metal plate. If the pencil consists of particles, these will strike against the molecules of the plate and will be deflected by the collisions—how much each particle is deflected is within certain limits very much a matter of chance, so that some particles will be deflected more than others. Thus when they emerge from the plate, the particles will not all be moving in the same direction; the stream of particles will spread out into a cone. This will make the image they form on the photographic plate larger and blurred—it will become a smudge without a definite pattern.

Suppose, however, that instead of a stream of particles we have a train of waves. Then, in consequence of the regular spacing of the molecules in the plate, the plate will act like a diffraction grating; and if the distance between the molecules is comparable with the length of the waves, we know from the properties of such gratings that when we interpose the plate in the way of the beam the original spot will *not* become just a smudge, but will be surrounded by a series of bright rings whose radii bear definite ratios to each other.

Now, it was found that when a beam of electrons was passed through the plate, instead of the smudge that might have been expected, the photographic plate showed a well developed system of concentric rings; furthermore, these rings were just in the position of the diffraction rings which would be produced if light of suitable wave length passed through the thin plate. A photograph made in this way with electrons is shown in Fig. 3. That these rings marked the path of electrons was shown by bringing a magnet near the photographic plate; the rings were displaced just as the path of electrons would be displaced. The deflection indicates clearly that the blackening of the plate is due to electrons and not to waves of light or X-rays, for these would not have been affected by a magnet.

Thus it appears that the electrons in their path through the metals are bent not like particles would be bent but in all respects like waves; hence, from these

experiments and from those of Davisson and Germer, we have no alternative but to conclude that the electron is accompanied by a train of waves and that these waves have complete control over its path.

By means of these experiments, the theory of de Broglie could be checked in three ways. First, the relative sizes of the rings should conform to the known crystal structure and for the metals used (chiefly gold, aluminum and platinum) the diameters of the successive rings should be in the ratio of the square roots of 3, 4, 8, 11, 12, 16, 19, 20 ——. The actual measurements it was found were in fair agreement with this rule.

Secondly, the theory predicted that the wave length should vary inversely as the momentum, i.e., the product of the diameter of any ring and the square root of the measured energy of the rays, subject to a relativity correction, should be constant. And it was found that these products were for gold 377, for aluminum 387, and for platinum 407, the applied voltage ranging from 18,000 to 64,000.

A third consequence of de Broglie's theory was that the actual size of the rings should be calculable from the assumed wave length of the electron and the known spacing of the atoms in the crystal. In this instance, the agreement found was obtained by working backward, that is by calculating the spacing from experiment and theory and comparing it with that found by X-rays.

Thus, in each case, the experiments checked within the limits of allowable error with the predictions of de Broglie's theory. It is thus quite certain that electrons are either composed entirely of waves or are always accompanied by a system of waves.

In a somewhat different way, Dempster has succeeded in diffracting protons, leading us to the conclusion that these also have wave properties.

Photographic Flame Studies in the Gasoline Engine

By Lloyd Withrow and T. A. Boyd*

BY MEANS of an ingenious apparatus, simultaneous pictures and pressure records have been taken of events during the explosion of the charge in the cylinder of a gasoline engine. The flame pictures were taken with a fast camera through a narrow quartz window that extended all the way across the ceiling of the combustion chamber. The length and location of this window were such that the entire progress of the flame, starting at the spark plug and ending at the far end of the combustion space, was visible in the camera.

The photographs taken by the camera were really moving pictures of the flame as it sped across from the spark plug to the end of the combustion chamber. But the pictures were not movies in the conventional sense. In this instance, the film moved; it moved in a direction at right angles to the axis of the window but at a constant speed, not by jerks, as in the conventional moving picture camera. Also, the shutter of the camera remained open during the photographing of one complete explosion. The image obtained, therefore, was all in one piece but spread out on the film in such a way that the curve forming its left-hand edge became a distance-time plot of the progress of the flame across the combustion space and the luminous portion to the rear of the flame front showed what was happening behind the flame front at any given time. The simultaneous pressure records, also taken photographically, were provided with means of matching pressures with corresponding events on the flame pictures.

These combined flame pictures and pressure records have now made it possible to speak with certainty about many of the things that happen in the gasoline engine. During the explosion of the charge, a flame, or narrow zone of combustion, starts at the spark plug and moves progressively through the charge. Oxidation of the fuel seems to be complete within this narrow zone of combustion but the products of combustion to the rear of the flame continue to emit light for some time. During normal or nonknocking combustion, the time required for the flame to travel across the combustion space was about 40 deg. of crankshaft revolution. For a car running 30 mi. per hr., this amounts to about 1/250 sec.

KNOCK COMES AFTER IGNITION

A knocking explosion differs from a nonknocking one only in the way the last portion of the charge burns. The difference is this: whereas in a nonknocking explosion the flame continues to move at a comparatively constant velocity clear to the end of the combustion space, in a knocking explosion the latter portion of the charge inflames at a much higher rate than normal. This rate of inflammation is usually so high, in fact, that at the instant of knock, which comes several degrees after ignition, the flame appears simultaneously throughout the whole of the portion of the charge still remaining to be burned.

The extremely high rate of inflammation which accompanies the knock, or which is the knock, is apparently due to anto-ignition or spontaneous inflammation occurring within the latter part of the charge. This auto-ignition may be caused by the high temperature induced there by compression resulting from the burning of the portion to the rear. But this spontaneous form of ignition is not pre-ignition, which in years gone by was thought to be the cause of knock. Pre-ignition occurs before the spark plug is fired. The knock does not come until 25 or 30 deg. after the spark.

Violence of knock is determined by how large a portion of the total charge is involved in the spontaneous inflammation or how much of it remains to be burned when the critical conditions that cause knock are reached. Right at the instant of this rapid inflammation or knock, an extremely rapid rise in cylinder pressure occurs. This fast mounting of pressure produces a force in the cylinder that acts somewhat like a sudden blow from a hammer, as distinguished from the more gradual push that results from a nonknocking explosion.

The one effect upon combustion of the presence in the gasoline of an anti-knock compound like lead tetraethyl, chief constituent of ethyl gasoline, is to prevent the extremely rapid inflammation of the latter portion of the charge and accompanying pressure rise, which is the knock. Lead tetraethyl has no apparent effect upon the velocity or the character of the flame prior to the time when knock would have occurred in its absence.

*General Motors Research Laboratories, Detroit, Mich. Abstract of paper presented at Indianapolis Meeting of American Chemical Society April, 1931.

Brine Race Systems for Freezing Ice

By Terry Mitchell*

TIME WAS when all ice-making tanks were built with stands of vertical pipe coils located between each row of cans: the earlier coils were made with cast iron headers or with screwed return bends at the ends of the long horizontal pipes. The continuous coil with electric-welded joints, similar to the type illustrated by Fig. 2, came as a great improvement, as did the principle of flooded operation. By installing an accumulator and flooding the coils, the heat transfer was increased and adjustment of the liquid feed became semi-automatic.

FIG. 1. A MODERN ICE PLANT

Continuous horizontal coils had their limitations, however, as the gas moving through the pipes tended to push the liquid ammonia ahead of it; friction caused by the long tortuous passage seriously reduced the outlet or suction pressure, upon which the capacity and efficiency of the compressor depended; there were a great many joints to be made up and kept tight; the coils could not be removed readily from the tank for repairs in case of injury or leakage; and the brine velocity over the pipes was so slow that between 250 and 350 ft. of 1¼-in. pipe was required, per ton of ice, to obtain the necessary transfer of heat.

Growing appreciation of these difficulties has resulted in improvements of three kinds: shell type brine coolers and new types of coil evaporators have been introduced; float control has made the ammonia feed fully automatic; and the rate of brine flow has been increased from about 10 ft. per minute to approximately 30 ft., between the cans, and to about 150 ft. per minute through the evaporator. The development of group methods of harvesting the ice, low pressure air agitation, and other refinements such as the duel-pressure system, with its precooled water and precooled liquid ammonia, have of course also influenced the design of the modern ice-making plant.

Omitting further reference to the float valve control and its remarkable effects, we will consider only the questions of evaporator design and brine flow. The submerged shell and tube brine cooler, once it had been given proper trial, offered a satisfactory answer to requirements for an efficient evaporator, and it holds its own, today, as the equal of any other type for ice plant work. Some engineers, however, prefer to keep the brine outside the tubes of the evaporator.

In answer to the continuing demand for more efficient coils of this type, what has been termed the Brine Race System, with a special evaporator made up of pipes and named the Vertiflow Unit, has been developed within recent years. The Race extends across the tank, usually at the end, and forms a restricted space through which the brine can be made to flow rapidly without giving it such excessive motion throughout the rest of the tank that the level would vary objectionably. The Race is short, and is open at the top, so that friction is reduced, and the horsepower required for agitation is kept within good limits. Agitation is improved by the use of an Axiflow impellor blade and special housing, inside of which are guide vanes to reduce churning: this agitator resembles, in principle, the low head pumps employed in irrigation work. The agitator may be either vertical or horizontal.

Race-ways can be built into the tank at one or both ends, or in the center, just as is practiced with submerged brine coolers. The Race System adapts itself admirably to float ammonia feed, dual-pressure operation, or complete automatic control. It is also utilized successfully in water cooling work, as in bottling or other industrial plants, as well as for the precooling of the water in the ice plant itself.

The Vertiflow Unit is designed to provide a series of short inclined pipes, through which the gas can be

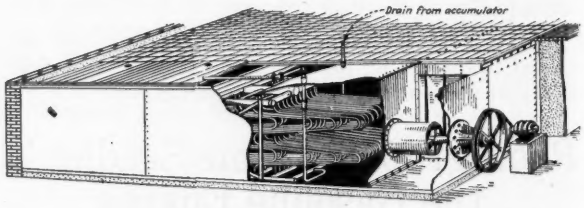
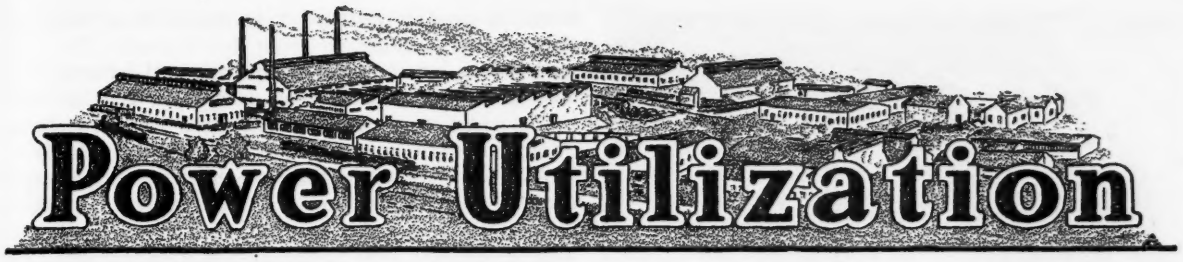


FIG. 2. SHOWING THE ARRANGEMENT AND CONSTRUCTION OF THE BRINE RACE SYSTEM FOR FREEZING ICE

rapidly liberated, and which can take full advantage of the faster flow of brine set up in the Race. The Unit consists essentially of five lengthwise headers, three at the top and two at the bottom, with rows of parallel cross headers welded horizontally between them. Vertiflow W-shaped bent pipes are then nested in the intervening space, as illustrated. The header in the center of the top is larger than the others, and serves as the main gas or suction connection to the various branch headers and pipes. The liquid ammonia is fed into the two bottom headers by a Y connection, at one end, while at the other end are placed the return or drain lines from the accumulator: a liquid pump is substituted for the accumulator in cases where the headroom is limited.

It is strengthened with a series of braces, and forms a compact evaporator which can be handled as one piece. While the pipes appear to be practically touching each other at places there is plenty of open space at the bends for passage of the brine. The headers are of proper size to keep the ammonia distribution uniform, and the pressure throughout nearly that of the suction line.

*M. E., The Frick Co., Waynesboro, Pa.



Replacement of Obsolete Motor Coils

Hand Wound Pushed In Form Wound

*By A. C. Roe**

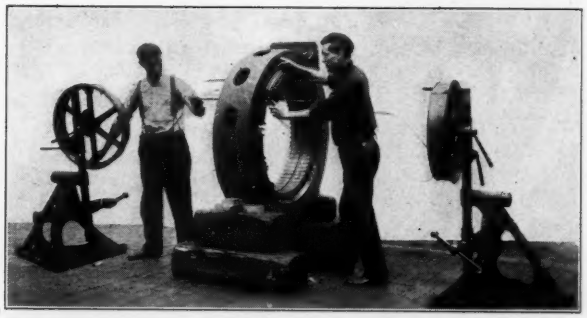


FIG. 1. HAND WINDING OF BENT COILS

MANY motors and generators, with windings of a type and design that have become obsolete, are operating daily and the method of supplying new coils for rewinding or repairing these machines has been materially improved by an electrical manufacturer, who has established an engineering and works organization devoted exclusively to the manufacturing of renewal parts.

Requests for coils to repair or rewind these older machines reveal the progress made in the windings of rotating electrical apparatus, as for example the gradual progress from one-coil per slot windings with coil types, to the present two-coil per slot, two-layer winding with one general type of coil.

In this article, an attempt will be made to indicate how modern windings can be employed in a number of cases to replace the older types, such substitution resulting, in the majority of cases, in lower replacement costs, reduced operating costs as a result of lower copper losses, also improved windings embodying present day engineering and manufacturing practices, using the latest materials.

When receiving an inquiry or an order for coils of an obsolete type, the electrical manufacturer has to consider the question of tools, cost of making, as compared to supplying a new design of modern construction and the advantages of the latter.

Coil Types

Cores of older machines can be divided into the same two groups as for present day machines, i. e., partly-closed slots and open slots. For partly closed slots, the windings fall into the two groups of hand-wound, or shoved-through, form-wound coils. The shape of the end windings is generally of the concentric chain type, using straight or bent coils. Open slot windings of the one-coil per slot type employed a number of coil types as concentric chain, involute dropped bottom, combination of involute and diamond.

At first, windings were placed into the slots by hand and shaped around wooden blocks, a turn at a time, as shown in Fig. 1. All the bent coils were wound into place first, close examination of Fig. 1 showing that the forming block is made for two coils and that alternate groups have one, then two bent coils.

Obviously, hand windings are expensive, requiring special tools and much skill to install. For voltages of 600 or less, the hand windings can be changed to the common two-layer, diamond-shape, mesh or promiscuous type of winding, using either the flat gang-mould coil, or pulled coil, with wires of each coil threaded through the slot openings and the coil ends taped. For higher voltage windings, the shove-through type of coil can be designed so that hand windings can practically be eliminated. Apart from being expensive to install, hand windings are hard to insulate and treat for high voltage use, hence do not last long.

Next a type of winding was tried, consisting of form-wound, continuous coils, with one end uninsulated, the remainder of the coil being completely insulated. The uninsulated end was bent up to clear the slot and the coil pushed through from one end of the core, as shown in Fig. 2. After the coil was in place, the ends were bent down and insulated. While this was an improvement over hand winding, it could not be applied to heavy conductors or high-voltage windings. This type can be replaced as outlined for hand winding.

Next to be tried was the open-end insulated shoved-

*Westinghouse Elec. & Mfg. Co.

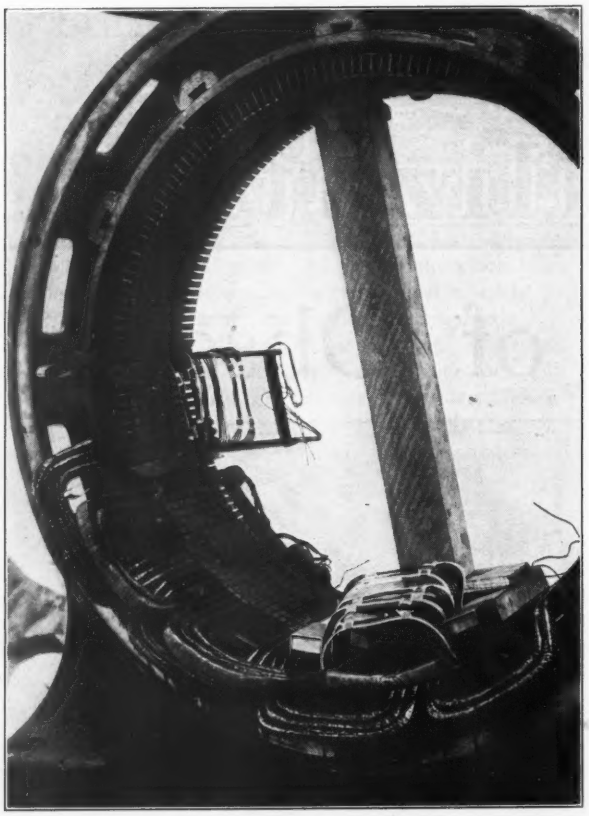


FIG. 2. PUSHED THROUGH WINDING OF FORMED COILS

through type of coil, the ends being bent and straight, Fig. 3. Note that the slot sections and rear end are completely insulated and treated. The coils were pushed through the slots from the end of the core, then the open end was formed, each turn connected with a sleeve connector and soldered, after which the joints and end were insulated.

Coils for shove-through windings were made up from round, square, or ribbon wire, or from bare copper strap. The possibility of changing to a modern type of winding, depends upon the voltage, turns per slot and type of conductor.

In changing the above windings to a more modern type, the major object is to reduce the cost of the replacement coils and re-winding, to reduce the total length of copper, which reduces the copper losses, and to eliminate the necessity of making expensive tools.

Open Slot Coils

Disadvantages of the types of windings used for partly closed slots led to the use of open slots and form-wound, completely-insulated coils. The first type of winding employed with open slots was the one-coil per slot, concentric chain winding, using straight and bent coils as shown in Fig. 4. The coils shown are for a low voltage and small capacity machine. Figure 5 shows a group of two coils for a high-voltage, concentric chain winding. The concentric chain type of winding required a number of different size coils as indicated in Figs. 4 and 5. This meant a large number of molds and, for certain combinations of slots, poles and phases, a special shaped group of coils would be necessary to close up the winding.

Next the involute type of coil was used for open-slot, one-coil per slot windings, as shown in Fig. 6, all coils in the same winding being the same size and shape. The main objection to this type of coil was the difficulty in winding the coils. When an involute coil consisted of more than one section, it was necessary to wind a number of single coils, then connect them together to form a complete coil. Also, when a wire of large cross section was used, it necessitated using two or more molds, to permit nesting or assembling the single coils together properly.

Another type of coil used for one-coil per slot open slot windings was the dropped bottom cell, two-layer, diamond end, as shown in Fig. 7. Note how each end of the bottom slot section is dropped, to permit the top half to pass. The end windings are of the present day, two-layer diamond type. This type of coil had the advantage that all coils per set were alike but the disadvantage of being extremely difficult and expensive to make, requiring special bending and forming tools.

For a short time, a complicated type of coil was used, a combination of the involute and diamond, two-layer and winding type, as shown in Fig. 8. The illustration shows the number of intricate bends and difficult forming that this type of coil would require in its construction.

Examination of Figs. 1 to 8 will reveal that all of the coils discussed contained a considerable length of conductor, due to the bending and shaping necessary to permit passing of the end turns. The copper losses were high and, due to the concentrated poorly distributed windings, the wave form was irregular and the self induction high.

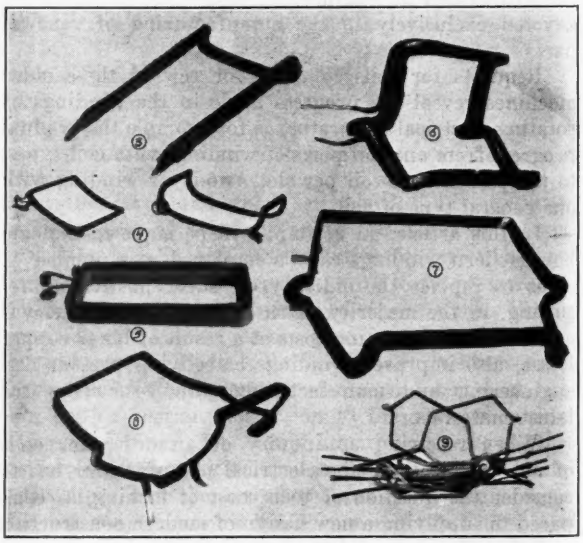


FIG. 3. OPEN END COIL FOR SHOVING THROUGH CLOSED SLOTS FIG. 4. COILS FOR CONCENTRIC CHAIN WINDINGS, STRAIGHT AND BENT TYPES FIG. 5. STRAIGHT COILS FOR HIGH-VOLTAGE CONCENTRIC WINDING FIG. 6. INVOLUTE COIL FOR ONE COIL PER SLOT FIG. 7. DROPPED BOTTOM CELL, TWO-LAYER COIL WITH DIAMOND ENDS FOR OPEN SLOTS FIG. 8. COMBINED INVOLUTE AND DIAMOND END COIL FOR OPEN SLOTS, TWO LAYERS, ONE COIL PER SLOT FIG. 9. INSULATED COILS FOR TWO-LAYER WINDING

Later machines all use the two-layer diamond pulled coil, with chorded coil pitch, overlapping phase belts and distributed windings. All coils for any one winding are similar as to shape and insulation and are manufactured on standard adjustable tools and fixtures.

Comparing the two-layer winding of Fig. 10 with Figs. 1 to 8, it is apparent that, although the two-layer windings require twice as many coils, as the one-coil per slot windings, the advantages regarding low replacement cost, low copper losses, less total length of copper and lower copper weights rest with the two-layer, diamond pulled coils.

Pulled coils for a two-layer winding are shown in Fig. 9 completely insulated and ready for the final varnish treatments. Leads of the coils have been made of sufficient length to permit their use as group connectors, thus eliminating cable jumpers.

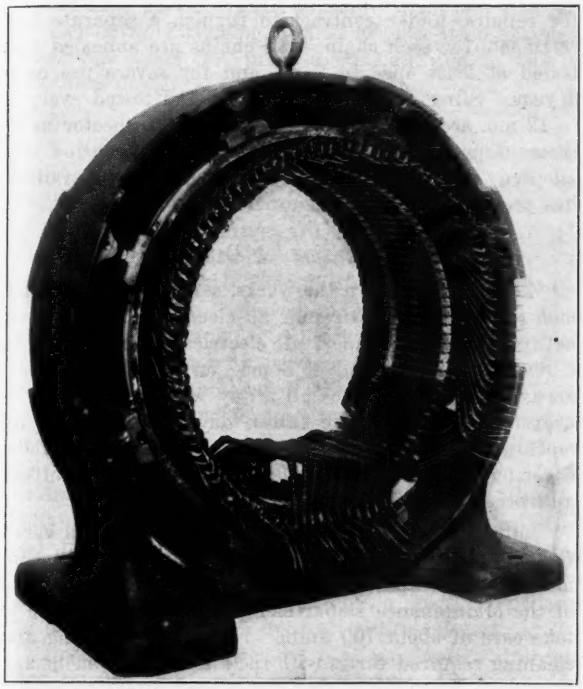


FIG. 10. MODERN TWO-LAYER DIAMOND COILS USED FOR A. C. STATOR

In some cases, it is possible to employ the two-layer type of winding to replace one of the older hand-wound, or one-coil per slot type. In the majority of cases, it has proved more economical to rewind a machine completely with modern two-layer coils, than to purchase and install a part set of the older type of coils. Thus when contemplating rewinding or repairing a machine having an old type winding, the manufacturer should be consulted as to the most economical type of replacement winding, as in the majority of cases, the operating costs, as well as the replacement costs of the two-layer type of winding will be less than for the older type.

FOR STEAM pipe a rule of thumb that works out quite well is: Velocity of steam in feet per minute flow should not exceed 1000 times the internal diameter of the pipe in inches.

Power Conveying *vs.* Muscle

ELIMINATION of 624 hr. a week of laborious material handling, of 90 per cent of spoilage due to careless handling and weather exposure, of the use of a tractor, 140 trailers and a lift truck and of congestion due to trucking are benefits secured from a conveyor system in the refrigerator department of General Electric Co.'s plant as described by H. C. Rundle before the second National Industrial Congress at Cleveland. In addition, the system serves as storage for parts in process thus releasing floor space and production in each department can be regulated to meet the capacity of the assembly line conveyor, thus avoiding both surplus and shortage of any parts. Parts from 1 oz. to 75 lb. in weight are handled at chain speed of 26.6 ft. a min., a total load of some 85 t. a day.

To prevent rust, passages between buildings were lined with ½ in. of celotex and heated by steam so that temperature is the same as in the buildings.

Automatic control of chain speed, limit switch for overload on the drive, equalization of pull between the three drives used and push button safety switches for emergency stopping of the conveyor are special features. When starting up, siren horns give warning to those near the conveyor for 10 sec. before the start.

As stop switches located at points in eight buildings locked the system so that personal attention was required before restarting, time was lost in locating the locked switch. To overcome this, each stop switch is connected to two lights in multiple on a panel board near the starting station, showing the operator at the control panel, by extinguishing the lights, which stop switch button has been pushed. The two in multiple guard against a signal from burning out of a lamp. The operator can communicate quickly with the stop station to find out whether the difficulty has been cleared so that the conveyor can be started. As shut-down stops the operation of three assembly lines, it is important to restart as soon as possible.

At all parts except loading and unloading stations, the conveyor is carried high above the floor and is protected with expanded metal and sheet iron guards, extending below the material conveyed and turned in so that it will catch any material that comes loose from the conveyor. At points where the line comes down for loading or unloading, umbrella sheet iron guards enclose all moving parts.

Carrying hooks are painted different colors according to the sections that they serve and spaced to give balanced flow of parts as between various stations, the feeding lines and the assembly line.

Thus, by connecting four sections in twelve buildings, uniform flow of materials has been secured and power transportation substituted for hard muscular labor.

WHEN USING portable lights with extension cords, use sockets of molded composition or porcelain, extra heavy cord, and protect the lamp from breakage by using an insulated guard. Extension cords used in damp places such as laundries, garages, and boiler rooms, should have special waterproof covering. Avoid bending or kinking the cord so as not to injure the protective covering of the wires.

Inspection Aids Equipment Maintenance*

Careful Selection, Proper Installation and Prevention of Breakdown Help Keep Buildings in Repair and Equipment in Operation. By August Heckman**

TO EXPEDITE the work, it is classified in five divisions: Works engineering; power plant; buildings and grounds; light, heat and electrical equipment; plant planning and layout.

Selection of equipment is made in the Works Engineering Department by specialists in conjunction with the various superintendents of production departments. Installation is done by the Maintenance Department under instruction from works engineering and to meet state laws and rules formulated by our Plant Safety Committee.

Prevention of breakdown involves anticipation of troubles, elimination of possible causes of failure and of hazards, by careful maintenance inspection. This covers: Cranes, hoists, runways and all their equipment; elevators and conveyors; pumping stations; heating and ventilating equipment; electrical system and equipment; all piping systems; police and fire alarm systems; power plant switching units.

Besides the maintenance inspectors' work, all maintenance foremen and supervisors report anything that might cause interruptions and inspectors in production departments report items which are hazardous or may hinder production.

As a subsidiary of the Works Joint Conference Committee, the Shop Regulations Committee, consisting of several supervisors and workmen, makes periodic inspections of the shop and submits recommendations as to keeping it clean and orderly, to avoid accidents, fires and breakdowns.

Reports

To be effective, inspection must be at periodic intervals, items being listed for inspection, with all findings and recommendations noted on report forms. These may be printed or mimeographed, according to the number needed but should give as many of the points to be covered by inspection as is feasible. Duplicate reports are sent to the repair department for information, most troubles being thus remedied before they become serious. But operators of equipment are held responsible for reporting any faults that appear between inspections. Reports, both periodic and casual are kept on file as a record and to check frequency of recurring faults as well as the work of operators and repair men.

Crane Chains

Prevention of accidents is most important. As an instance, overhead cranes and hoists use wire rope or chain. Rope can easily be inspected and should be at least monthly. Visual inspection of chain, however, is insufficient to determine its safety. After several chain failures, a committee was appointed to investigate and submit recommendations. It was found that no two companies in the Pittsburgh district handled chains alike as to materials, annealing or safe load allowance and no plant had any means of testing chains after repair and annealing.

As a result, chains of the best grade of Swedish iron, annealed at 1325 to 1375 deg. F. were recommended, also a proof test. But, as forging, annealing and testing equipment would cost some $65,000, an investment not warranted by the use to be made of it, it was decided that all chains be sent to a nearby chain manufacturer for repairs, under contract to furnish a separate test certificate for each chain. All chains are annealed and tested at least once in 2 yr. and for severe use once a year. Sling chains are annealed and tested every 3 to 12 mo. according to judgment of the inspector as to their usage. During the 2 yr. since this routine was adopted, with some 3000 chains in service, no failure has occurred except from overloading.

Allocation of Duties

Zones are set up in the works, serviced by 20 repair men to anticipate and repair all electrical troubles and, between times, to inspect all electrical equipment. As a result, over a period of 3 mo., on cranes and hoists an average of 1 trouble call a day was received per 39 units; on elevators, one call a day per 19 units; on machine tool motors one call a day per 148 units; these covering trouble on controllers, resistors, push buttons and other auxiliary devices.

Lubrication and cleaning of machine tools is cared for by the operators. For all other electrical and mechanical equipment, responsibility is on one section of the Maintenance Department, one man being able to take care of about 700 units. Frequency of oiling and cleaning required varies with the kind of equipment and bearings. High-speed ring oilers need attention once a day, some ball bearings only once in 3 to 6 mo.; but it is good practice for the oiler to look over every unit at least once a week, regardless of the frequency of lubricating and cleaning.

For woodworking machinery, also for forges, foundries and other exposure to abrasive dust, motors should be blown out at least once a week and motors in general once a month unless they are dust and vapor proof. Then they should be opened up at least every 6 mo. for examination.

Cranes are cleaned and lubricated by the cranemen, a few where no hazard is involved, during regular hours, the remainder in 15 min. overtime. Foundry cranes are, in addition, thoroughly cleaned every Saturday afternoon.

To avoid neglect of "everybody's business," inspection of grounds and buildings, instead of being divided among groups, is delegated to one person, who attends to details of structures, sewers, piping, tracks, yards, floor loading and the like.

*From a paper before the National Management Congress, A.S.M.E., at Cleveland.

**Superintendent, Buildings, Light, Heat & Power Dept., Westinghouse Elec. & Mfg. Co.

Especially on new work, time study and an incentive wage have resulted in savings and met with approval of the workers. Typical savings are: For concreting and hand painting 20 per cent; carpenters and pipe covering, 25 per cent; labor, roofing, pipefitting and sheet metal work, 30 per cent; structural steel, 35 per cent; spray painting and wiring 40 per cent; janitors 45 per cent. Timing of operators, better planning of work and suggestions by the men themselves have brought about these results, with better pay for the men and a spirit to avoid delay so that maximum wage may be secured. As an instance, in spray painting, thirteen men were in a group using two tanks and four men operating spray guns, while the rest covered and uncovered material, moved scaffolds and brought paint material. By study, the group was reduced to ten, six men operating spray guns from three tanks and four doing the moving. After a time, the group leader observed that he could work efficiently with one man less.

Repair work is being studied to place it on an incentive wage basis but progress is slow due to lack of adequate data.

Schedules and Standards

To ensure that building details such as metal window frames, crane runways, bridges, smokestacks, tanks and the like are safeguarded against deterioration, schedules of repairs and painting are laid out by the Works Engineering Department allotting various classes of work to certain periods so that cost can be budgeted.

Also standards, believed to be the best and latest practice, are set up for construction and installation, to avoid variation with personality of the workmen, to make easier the spotting of trouble, to expedite work, to minimize cost and to permit minimum of spare parts in stock. These standards involve accessibility for inspection and replacements and conformity to state laws. In the case of cast or sheet metal guards, holding by bolts and nuts so that removal of guards for inspection and lubrication is a bother, may result in throwing away the guards or neglect of inspection. Facility in maintenance by use of hinges, sliding doors or snaps is, we believe worth while, even at additional cost.

Inspectors and foremen pay particular attention that repairs and replacements comply with state laws and ordinances to avoid report by state inspectors of violations with consequent bother and expense of rectification.

We believe that maintenance inspection is necessary to secure standard installation, to lower costs, to prevent breakdown of equipment, to eliminate hazards, to promote morale of workers and to insure better continuity of production service, which results in lower manufacturing cost of product.

Taylor stokers equipped with straight line drive and rotary ash discharge have been purchased from American Engineering Co., Philadelphia, Pa., by Charles Lennig & Co., Inc., for its plant at Bridesburg, Philadelphia, Pa. A-E-Co side and rear water walls for the furnaces were included in the contract. The present dump plate stokers which have been in service six years will be modernized and installed in the boiler plant of Rohm & Haas Co., an affiliated organization at Bristol, Pa.

Standard Gas & Electric Co. Shows Customer Increase

Standard Gas and Electric Co. and subsidiary and affiliated companies had consolidated surplus earnings of $13,082,498 for 1930 after all operating expenses, interest charges and preferred dividends, or the equivalent of $6.04 a share on the 2,162,607 shares of common stock outstanding December 31, 1930, according to the company's annual report recently issued. This compares with a surplus of $10,298,053 for 1929, or $6.59 a share on the 1,562,607 shares of common stock outstanding at the end of that year. Standard Gas and Electric Co. and subsidiary and affiliated companies had combined assets of $1,204,858,329 on December 31, 1930.

Gross earnings of Standard Gas and Electric Co.'s subsidiary and affiliated public utility companies decreased $904,968, or 0.58 per cent and net earnings before appropriation for retirement of property and depletion decreased $769,806, or 1.03 per cent.

Earnings of the subsidiary and affiliated public utilities companies were adversely affected by the general business depression and drouth conditions which reduced the output of hydroelectric power and necessitated increased steam electric generation, according to John J. O'Brien, president of the company. Deep Rock Oil Corp. and subsidiary and affiliated companies' net earnings were reduced by proration of oil production and lower prices prevailing in the industry.

Now the company's public utility system serves a total of 1648 communities having a combined estimated population of six million, 51 communities having been added to the properties comprising the system during 1930. On December 31, 1930, a total of 1,617,414 customers of all classes was served, an increase during the year of 36,759 customers, or 2.32 per cent.

Electric connected load or business served increased 189,611 kw., or 6.07 per cent, to a total of 3,312,475 kw. Electric energy output for the year amounted to 4,594,752,028 kw-hr., an increase of 0.94 per cent, while gas output was 46,247,039,000 cu. ft., a decrease of 0.34 per cent.

Net construction expenditures of the subsidiary and affiliated public utility companies during 1930 totaled $40,608,887. Electric generating capacity increased 144,917 kw. during the year. As of December 31, 1930, the aggregate capacity of the generating plants of the subsidiary and affiliated public utility companies was 1,539,637 kw.

The construction budget for 1931 totals $45,068,000, of which $30,793,000 is for new projects while $14,275,000 is for completion of work started prior to January 1, 1931. Of the total budget $8,229,000 is for extensions to serve new business.

Halford Erickson, vice president in charge of operation, Byllesby Engineering and Management Corp., announces that plans are being made for the completion of the Prospect hydroelectric project of The California Oregon Power Co. on the Rogue River in Southern Oregon. Completion of this project will necessitate the employment of a considerable number of men during the construction months and, consistent with the company's policy, efforts will be made to employ local labor in so far as is possible.

Combustible Storage Rooms

MANY INDUSTRIES find it necessary to store and handle considerable quantities of combustible fibers such as cotton linters and waste, jute, hemp, excelsior, Spanish moss, oakum and kapok. Such materials even if baled have a high flash hazard; that is, the unconfined fibers are highly combustible and the fire spreads over the entire mass very quickly. Chemical fireproofing can be used to a certain extent but this is expensive and not always practical. The best method is to follow the regulations of the National Board of Fire Underwriters.

Warehouses must of course be of fire-proof construction and be equipped with fire extinguishers as well as a sprinkler system. Power boilers and fuel storage must be in a detached building or separated from the warehouse by standard fire-proof construction with connection to the boiler room only from the outside. In general, this also applies to heating boilers except when gas is used, in which case a self closing fire door is permitted. Engine rooms must have the openings into the warehouse separated by fire doors on both sides of the wall. Heating is permitted only to keep the sprinkler system from freezing and should be either low pressure steam (not over 15 lb.) or hot water.

Fixed motors may be used if they and their starters are enclosed in a room of such a construction that it will withstand a one-hour fire test. Portable motors must be of the totally enclosed or explosion proof type. Conductors must be installed in metal conduit and switches and fuses put in readily accessible metal cabinets outside of the storage space. When any compartment is closed, all the electrical equipment must be disconnected. In order to make sure of this, a pilot light or lights must be used at each entrance in the main circuit without a switch so that it lights whenever the main switch is closed.

Incandescent lights are the only safe ones to use and should be carefully placed so that they will not be broken. When special lights are needed, use electric battery lamps, never oil lanterns or extension cords. Wiring should be not less than No. 14 B.&S. enclosed in metal equivalent to rigid steel conduit. Lamps and sockets should be enclosed in vapor proof globes or metal reflectors fitted with wired glass bottoms, so that in case of a burnout hot particles will not fall on the stored material.

Brooklyn, N. Y. F. PAUL.

Pulverized Coal Plant for Ships

IN THE interesting and well presented article by Dr. Ing. Emil Goos describing the system of powdered fuel installed on the S. S. Strassfurt of the Hamburg-American Line, it is noted that Dr. Goos states that "After exhaustive consideration, the Hamburg-American Line chose the Clarke Chapman system, since its arrangement of mills promised safer operation of the pipe line system and the plant is not too complicated." He further states in the same paragraph that business affiliations also influenced this choice.

In connection with the statement regarding the use of the pipe line or loop system, I would say that, at the time the United States Government was conducting its experiments and investigations relative to the application of pulverized fuel to marine installation, the idea of the loop system was definitely abandoned due to the fact that they found in their investigations, that a great deal of the fear relative to the use of pulverized fuel had been caused by this same loop system, which is in a sense a modification of the storage system. In the loop system there is always the danger of hydrocarbons collecting in dead spaces caused by eddies in the line and this collection of hydrocarbon gases has an unfortunate habit of exploding; in fact it was found that the practice had even been adopted of periodically sweeping the loop lines with ash in order to scrub away these pockets of hydrocarbon gases.

After giving due consideration to the loop system and the hazards which attended it, the idea was abandoned and the unit system with distribution accomplished through a distributor head was adopted.

In Dr. Goos' summary of systems of powdered coal firing that have come predominantly into use on American and British ships, he omitted the unit system with distributor head and attention is brought to this fact inasmuch as possibly 25 per cent of the total marine installations made to date have employed this system. I would state that the first marine installation made in this country, which was on the tow boat, the S. S. Illinois, fitted with the Kennedy-Van Saun system, employs the distributor head and this vessel has now been in service since 1927. Also, the first off-shore marine installation, which was made by the United States Shipping Board on the S. S. Mercer likewise employed the Kennedy-Van Saun distributor head system. This vessel has now made over 100,000 mi. and at no time has she

failed to meet her sailing schedule, nor has she had any delays throughout this 100,000 mi. due to the pulverized fuel system.

Relative to the complications of this system, it is to be noted that this vessel was taken out of port by a chief engineer who had never been on board her before and, with such instructions as could be given by one of the Government engineers on her trip from Baltimore to Boston, he proceeded to take her across the Atlantic and to effect a fuel performance on a par with that which had been set as a standard on her initial voyage when she carried a corps of expert engineers who were conducting a service test.

New York, N. Y. C. J. JEFFERSON.

ON THE contents page of the May 1 issue, you ask for some disciple of Father Noah to present his side of the question.

Being a lineal descendant of the old man and, having had experience both with powdered coal and Noah's method of propulsion, I herewith present my brief.

In my boyhood, I had a homemade catamaran and a pond of water, the means of progress being achieved by a long pole. After getting a short distance from shore, the water was too deep to use the pole, so I had to depend on the wind to take me to the other shore and, on calm days, would be marooned for hours.

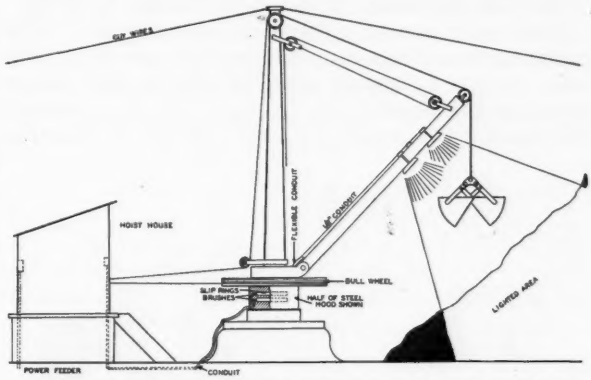
Don't be too sure of your premise that the ark did not have sails because no picture was taken of it showing either sails or black smoke. Remember the story of Michael Angelo, who painted an angel wearing sandals? Some critic said, "Who ever saw an angel with sandals?" Mike answered, "Who ever saw an angel without sandals?" In Noah's day, photography was in a rather crude way. (Am trying to think of some allusion to my old friend Benveneuto Cellini, who invented the wheelbarrow, but cannot.) Getting to the modern side of the discussion, powdered coal is an improvement on hand stoking, but it has some drawbacks. The drying and pulverizing machinery are expensive and bulky, the last being a serious drawback on shipboard. Some coal contains slate and pyrite, the latter being particularly objectionable on account of the rapid wear of the comminutors; I have tried manganese and chrome steels, tungsten and other self hardening steels, and the wear is terrific. Powdered coal is highly explosive when mixed with air in the right proportions, and while its proponents claim that it can be pumped through a pipe, experiments in coaling at sea have been unsuccessful. This does not apply in the case cited by Dr. Goos, as the coal is loaded at a home port, and is powdered as used. The semi-bituminous coals of Cambria Co., Pa., Western Maryland, and the Virginias are well adapted to this class of work, being low in moisture, ash and sulphur, and in a friable nature as mined.

The present conditions in the fuel oil industry and the ever widening supply in countries other than ours, would seem to me to preclude any other form of fuel for marine use. The reduction in bulk, ease of handling and loading, safety from explosion and spontaneous combustion, and high capacity afforded in properly lined furnaces, have made it preëminent in the Navy, where all possible plans of fuel combustion have been made a study for years.

Cleveland, O. L. R. BAKER.

Revolving Derrick Electrically Lighted

SEVERAL YEARS ago the writer placed electric lights on a yard derrick, used in bringing coal from a stock pile to the conveyor that carried the coal to the boiler room. Lighting was needed when the activities of the plant required night operation. Due to the fact that the derrick made nearly a complete circular movement, connection between the wiring and the hoist house was the main difficulty, as it was necessary that this connection be extremely flexible. The difficulty was solved by placing two slip rings near the bottom end of the mast,



ELECTRIC LAMPS LIGHT AREA COVERED BY BUCKET

to which the boom wiring was attached. As 220-v. power was used to operate the motors, it was decided to use this voltage on the lighting, although the remainder of the plant lighting was on 110 v. Lamp fixtures, however, were wired in series so the standard 110-v., 500-w. lamps could be used on the derrick. A sheet iron hood was attached to the bottom of the bull wheel to protect the slip rings and brushes from rain and snow. The operator always had light where it did the most good, regardless of the position of the boom. The sketch shows the relative location of the various parts.

Cold Spring, Minn. CHAS. A. PETERSON.

Cylinder Drain Botched

AS THE NEW engineer was looking the equipment over for the first time, he approached the cylinder of a horizontal steam engine that drove a large centrifugal blower and noticed a peculiar whistling sound as of a blast of steam blowing to waste somewhere. When his eye caught the drainage arrangement shown in Fig. 1, he knew the cause of it.

Inquiry disclosed that, about 4 mo. before, a truck load of iron was overturned while it was being trundled alongside the engine and wrecked the drain piping. The handyman on the job repaired the damage with the

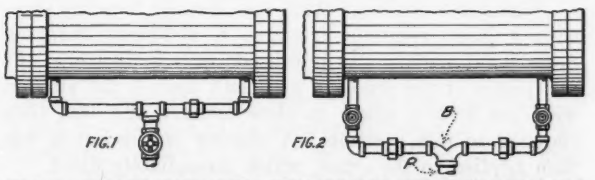


FIG. 1. DRAIN PIPE BYPASSES STEAM FROM END TO END OF CYLINDER. FIG. 2. CORRECT DRAINAGE ARRANGEMENT.

result that steam shot through the drain pipe, from end to end of the cylinder, at every stroke of the piston.

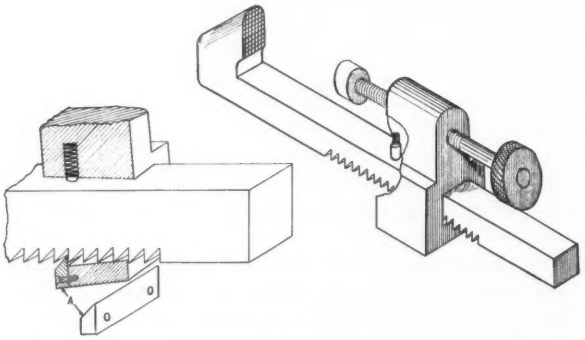
Figure 2 shows how the job was altered. With the double-branch elbow B at the junction of the leads from the cylinder, the two currents of drainage water issuing while the engine is being put in service are deflected into the main pipe P so that there is no interference.

What struck the new engineer as rather remarkable was that no one connected with the plant seemed to realize that anything was wrong with the blower engine.

D. J. ALTIZER.

Quick-Acting Wide-Opening Clamp

ONE OF THE most widely used clamps is the C type with its various sizes of openings. It is necessary, however, to have a complete range of sizes for fast, proper work for if a large size clamp, say a 6-in. clamp, is used to clamp a 2-in. piece, the screw will not be effective.



QUICK-ACTING CLAMP

Such a use tends to distort the clamp, to cause it to skid off at a tangent to its line of proper bearing, also it takes considerable time to screw it to its seat.

For those who like to make good use of the plant machine shop, a really rugged and quick acting type of C bar clamp that permits the use of a short and rigid screw is shown here. No great amount of time nor skill are needed to make a set of these clamps.

The back of the clamp body or bar is notched or toothed as shown and the sliding jaw is provided with a concealed spring plunger to actuate the jaw into place as it is moved from place to place on the bar. Details of this jaw are shown in the small enlarged view of it. Clearance is at an angle from the front to the back of the inside of this jaw to permit canting or tipping the jaw forward to release the engaging tooth. This tooth or key, that fits into the teeth of the clamp bar, is secured to the jaw by two screws as shown at A.

Concord, N. H. CHAS. H. WILLEY.

Repairing Celluloid Instruments

WHILE DRYING some fresh ink lines by fanning them with a large celluloid triangle, it suddenly snapped. Some amyl acetate was purchased at a drug store; the two pieces of the triangle were laid upon a flat surface with the broken edges in close contact and was then clamped in this position. A coating of the liquid was then applied to the crack, which immediately filled.

This coating was allowed to dry for a few minutes and then another was applied. The surface of the triangle was then coated with amyl acetate and a piece of thin celluloid photographic film with the emulsion removed was coated in a like manner. This was placed over the crack with the edges extending a few inches beyond the crack and overlapping the edges of the triangle. This treatment was then accorded the opposite side of the triangle and after trimming the overlapping edges and sandpapering the edges in contact with the triangle so that a smooth surface was obtained, the job was completed.

Since then the same method of repair has been used with various celluloid articles and always with satisfactory results and at a negligible cost.

Chicago, Ill. T. HANSON.

Quick Freezing for Pipe Repairs

I AM NOT satisfied with the letter of John Thorn under the above heading in the May 1 number of Power Plant Engineering, page 524, for the reason that Mr. Thorn himself does not appear to be "certain" that a cast-iron pipe would crack if frozen locally by means of solid carbon dioxide or "dry ice" as it is sometimes called.

In the original article, it was stated that cast-iron water pipes had been frozen without cracking the pipe and Mr. Thorn says he is surprised.

My belief is that a cast-iron pipe will not crack if frozen in a local spot a few inches long because freezing, if my understanding of the action of freezing is correct, does not create pressure unless the containing vessel is confined. In an ordinary pipe line there usually is sufficient give in both directions to take care of the slight increase in volume of the short length frozen.

If the water is in motion at the time of freezing, and it certainly must be in motion if there is a leak, the action would be quite similar to the action in an agitated ice can. Ice cans, as every reader of Power Plant Engineering knows, are used over and over. There is no stretch or expansion due to freezing because of the continual motion of the water.

Mr. Thorn says, "No pipe can be frozen if any valve or cock allows a leak or even a quick drop." This is contrary to the writer's experience in operating a small power plant in the middle west where temperatures sometimes go down to 40 below zero.

In one of my experiences, the 3-in. exhaust pipe stuck out into the open a distance of about 6 ft. This pipe froze solid over night due to condensation and constant drip. When I turned on the steam the next day the engine ran for a short time and then stopped. It stopped because the back pressure became equal to the live steam pressure, and when that happens any engine will stop. Of course this experience is not identical with the ordinary freezing of water pipes, but I have had plenty of experience with water pipes freezing even though there was a constant leak. Some pipes have burst, too, but not when only a short length was frozen. When a great length freezes, then look out for the bursting act.

Newark, N. J. W. F. SCHAPHORST.

EVERY ENGINEER should consider himself a consulting engineer retained to improve operation and reduce operating costs.

Cleaning Injectors with Acid

NOTING R. B.'s request for a method of cleaning his injector, it occurred to me that our experience along that line might be interesting, not only to him but others. We use muriatic acid to clean almost anything that is limed up that is of a shape or construction that makes it difficult to disassemble, such as injectors, gas engine or air compressor, sometimes in feed piping where it is less cost to pickle than to take down, but we use a much stronger solution than that recommended, often using it full strength, never less than half. It is extremely active in these proportions but there need be no fear of injuring either iron or brass unless left in contact for a considerable period, but it will in the course of weeks destroy iron, brass, lead or anything I tried except rubber. We were trying to heat a muriatic acid solution or rather a mixture of acid and water by means of a steam coil but did not find anything that would last for any great length of time, but for removing lime the exposure is not long enough to do any damage.

In pickling gas engine jackets or anything where the gas generated does not escape freely, care should be taken that it does not blow into the face or eyes. In carload lots it costs only about 12 cents a gallon and as it is used in the manufacturing process we always have a good stock to draw from and quite often find it the cheapest way to clean out a piece of apparatus.

Anderson, Ind. J. O. BENEFIEL.

Boiler Calculations

HOW DO you figure the working pressure on a steam drum of a water-tube boiler? 2. How do you figure the bumped head on the steam drum of a water-tube boiler?

M. S.

A. The maximum pressure to be allowed on a steel or wrought-iron shell or drum of a boiler is determined from the minimum thickness of the shell plates, the lowest tensile strength of the plates, the efficiency of the longitudinal joint, the inside diameter of the outside course and the lowest factor of safety allowed by the steam boiler rules, the formula being:

$$P = \frac{T.S. \times t \times E}{R \times FS}$$

Where

P = maximum allowable working pressure per square inch, in pounds.

T.S. = tensile strength of shell plates, in pounds.

t = minimum thickness of shell plates, in inches.

E = efficiency of longitudinal joint, method of determining which is given in paragraphs A-1 to A-7 A.S.M.E. Boiler Construction Code.

R = radius = one-half the inside diameter of the weakest course of the shell or drum.

F.S. = factor of safety allowed by the code is 5 for new construction.

2. The minimum thickness of a convex head curved outward from the shell when it is a segment of a sphere is determined by the following formula, taken from the A.S.M.E. Boiler Construction Code.

$$t = \frac{5.5 \times R \times P}{2 \times T.S.} + \frac{1}{8}$$

Where

R = one-half the radius to which the head is dished unless the radius is less than 80 per cent of the diameter of the drum in which case L is taken as 80 per cent of the diameter of the drum.

P = working pressure, in pounds per square inch, for which the boiler is designed.

T.S. = tensile strength, in pounds per square inch, stamped on the head by the manufacturer.

t = thickness of head, in inches.

Unstayed dished heads with the pressure on the convex side shall have a maximum allowable working pressure equal 60 per cent of that for heads of the same dimensions with the pressure on the concave side.

Strong Aqua Concentrations

ASSUMING NO pressure drop between the evaporator and absorber and a temperature of —17 deg. F. in the evaporator of an absorption system,what must be the temperature of the strong aqua ammonia to insure a concentration of 38 per cent in the absorber?

A. H.

A. A temperature of —17 deg. F. corresponds to an evaporator pressure of 19.81 lb. per sq. in. abs. or about 5.1 gage. In order to have a 38 per cent concentration in the absorber at this pressure, it would be necessary to maintain a temperature of 72 deg. F.

Usually, however, there is some drop, often from 2 to 5 lb., due to piping between the evaporator and the absorber and if the system is not purged regularly, air and noncondensive gases may increase this an additional 2 or 3 lb. Instead of an absorber pressure of 5 lb. gage, therefore, pressure may be up as high as 10 lb. gage or about 25 lb. absolute. In order to maintain a 38 per cent concentration at this higher pressure, a temperature of 83 deg. F. would be sufficient.

Editorial Comment

A Standard Set for Utility Management

For two years the Federal Trade Commission has been carrying on investigations of the most prominent public utility corporations in the country. These investigations were initiated through the demands of certain members of the U. S. Senate with the obvious desire, so it has developed, of placing these corporations in the category of violators of the antitrust laws of the United States and thus giving an opportunity for dissolving or at least seriously restricting the activities of these corporations.

Throughout the entire procedure representatives of corporations have been put on the witness stand in the manner of suspected criminals before a court. They have been subjected to cross-examinations of the most rigorous and insinuating type; many of the questions asked involving figures and dates available to the commission in the corporations records.

When vociferous senators laid the challenge down to the public utility corporations that an investigation would reveal an insidious trust this challenge was accepted in the hope, unquestionably, that, by placing all information relative to the operations of utility corporations at the disposal of the commission, the publicity which this information would receive would so redound to the credit of the utilities that the public, with undisputed facts before it, would give little attention to the malicious criticism which, for a number of years, has been aimed at privately owned public utility power corporations.

For two years now these hearings have been in progress. So far, little has been accomplished, of value either to the public as power users or the corporations as power distributors. Investors have seen various corporation and holding company officials put on the stand and grilled for days at a time with questions intended to prove them financial manipulators, dangerous to the wellbeing of the nation. As yet the commission has failed to uncover a trust, in the legal sense of the word, among the power utilities.

At least, however, a ray of hope that the investigation may be of some little value has put in its appearance in the report made by Judson C. Dickerman, Commission Engineer Examiner, relative to the management of the Cleveland Electric Illuminating Co. which was described "as closely approaching that which may be expected of a public utility under good conservative management which conforms to the best ideals of public regulation.

"There is no inflation, no subordination of the local company to the holding company. The security issues are thoroughly secured both by property and earnings, the rates are low and provide moderate cost service to small consumers and low priced service to industrialists and, judging from the facilities provided, personnel in charge and the operating results, service must be of high grade."

It was stated that "The company appears to maintain exceptionally good relations with the Public Utilities Commission of Ohio. Its reports are complete and clear. It files annual detailed statements of its property additions so that costs can be identified directly with the property where located. Its rate schedules are among the simplest in form, number and terms that are anywhere in use."

Such words of commendation from an authority as high as Mr. Dickerman are worthy of note at any time but especially so under the circumstances which have so far surrounded these investigations.

If the management of the Cleveland Electric Illuminating Co. is so meritorious as to meet in the way it has the approval of the Commission, it has set a pattern well worth study by managers of other utility corporations. With such a standard set and rigidly adhered to, investigations such as we have been witnessing would soon develop into an examination of auditors' reports without newspaper headline interest. Perhaps, after all, the investigation will point a way to prevent the power utility industry from becoming a political football, the danger of which is now imminent.

Contract Ice

One of the most effective methods of getting new customers and increasing ice business yet developed is the new "contract ice," put into effect during the past year by ice companies in several sections of the country. In most cases, the driver is made the salesman and assumes the responsibility of keeping the customer's refrigerator iced for a certain number of months. This is done for a flat rate on contracts ranging from the five winter months in some sections of the country to a full twelve months in other sections.

One company in Kansas has a flat rate contract covering the five months from November to March inclusive, the rate varying from $8 for a 50-lb. refrigerator to $11.50 for a 150-lb. refrigerator. Similar prices for a four-months' contract in Oklahoma range from $5 for a 50-lb. contract to $8 for 150-lb. contract. These prices were based on an average consumption of 11 lb. per day, taken from past records. Actual consumption for November, December and January were respectively: 15, 12 and 11.36 lb. per day per box. Another company in the same territory offered a supply contract for a year for $36 with each 100-lb. refrigerator sold.

In another district where actual records were kept of contract customers, the average consumption per day per box was 18.9 lb. for November, 13 lb. for December and 18.5 lb. for January. The average consumption for the different types of boxes being 16.9, 19.3, 23.2 and 29.4 for the 50, 75, 100, and 150-lb. boxes respectively. Actual consumption ranged from 10 to 25 per cent above the estimate.

Under this system, the company gets complete control of the ice chamber and it is up to the delivery man to see that the refrigerator is properly iced. This program is new and has already proved effective, combating competition and increasing the tonnage in the off season. One company alone has 9000 customers on contracts in 50 cities extending through four states.

Ice plants make a desirable load for the power plant and stabilization of ice consumption by the new contract basis should do much to improve load conditions throughout the year. Formerly, in winter the ice load fell off to a fraction of its summer value, making it a negligible factor in many cases. The introduction of cheap contract ice has, however, changed the situation materially, not only during the winter months but during the summer months as well. The customer being favorably impressed by the advantages of contract service during the winter months, is unlikely to discontinue it during the summer months. The practice has already demonstrated the value of contracts in building up tonnage and stabilizing conditions for the ice dealer. From the standpoint of the power plant, each ton of ice represents from 40 to 75 kw-hr., of a most desirable type of load. Contract ice is a stability insurance and an effective weapon for the ice dealer against competition and should show an appreciable load increase, ranging from 10 to 100 per cent, for the electric power system.

Inside Information

Observing the machinery in operation in a great power plant we have sometimes wondered what the effect on operation would be, if the engineer could actually look into a boiler or a pump or the high-pressure cylinder of a turbine and watch the processes that are actually taking place or if he could have a motion picture of them. True, it is possible to put windows in the low pressure casting of a turbine (we have seen two or three so equipped) where the temperature is low and the pressure is mostly vacuum. But that is about as far as engineers have gone.

It would seem, however, that with our present skill in designing mechanisms, we ought to be able to devise a method for direct observation of the inside of operating equipment. Possibly there is too little demand for it. Many engineers might question whether actual observation of the action of water and the formation of steam inside the tubes and drums of a boiler in full operation would give them as much information about what is really going on as would proper chemical analyses of water during operation and examination of the boiler material after a given period of operation with that water. Perhaps observation would be more a matter of interest than of scientific value but we don't know that definitely until we have tried it. Water circulation in glass model boilers, for example, has not always been found the same as that in full-size units of the same proportions under working conditions.

We feel that we know a great deal about what actually goes on in steam turbines, pumps, engine cylinders, heaters, fans, traps and other power plant equipment. Yet can we not imagine that study of many of the seemingly unimportant details might lead to important improvements if they could be observed directly and possibly photographed?

That this idea is not too far-fetched is indicated by the recent development of equipment for photographing directly the combustion process that occurs in the cylinder of a gasoline engine. Elsewhere in this issue is a discussion of this unusual procedure. It results in some diagrams showing the relations between flame propagation, time and pressure in the cylinder and these diagrams are of the highest value in analyzing combustion conditions in the cylinder, especially with regard to knocking.

Thus, as we pointed out above, there has been enough work done in the examination of conditions inside machinery during operation to indicate that such examination is feasible and valuable in many cases. If any great demand develops for similar studies of processes inside steam machinery there it little doubt that somebody will find a way to make them. They might be extremely valuable and without question they would be interesting.

Food Preservation

Recent investigation in the preservation and storage of food has done much to increase our knowledge of this subject. These investigations have been instigated and carried on largely by those interested in the newly developed quick-freezing processes and their findings have changed many theories upon which past practices were founded. The two most serious sources of deterioration during cold storage are desiccation and oxidation. Desiccation or drying causes serious shrinkage, ruins the appearance of the product, and often affects its flavor. Oxidation during storage takes place rapidly when the product is freely exposed to the air of a storage room. In flesh products, such as oily fish and fat meats, rancidity is one of the most noticeable effects. In lean fish, such as haddock, oxidation or enzymatic action is responsible for the appearance of a salt-fishy flavor. With fruits and vegetables, this action manifests itself in changes in odor and flavor.

Laboratory work during the past year has indicated that the period during which a frozen product may be kept is inversely proportional to the temperature at which it is held. At 15 deg. F., frozen haddock filets remain in perfect condition no longer than three months; at 0 deg. F., they may be kept for a period of six months, while at a temperature —20 deg. F., they may be kept in excellent condition for nine months or longer. In the case of fatty fish, such as mackerel filets, this temperature is still more important because of the oxidation or rancidity which takes place.

Fruits and vegetables should be kept at temperatures not higher than 0 deg. F. and much lower if possible, according to the findings of this laboratory. Spinach, peas, string beans, asparagus and sweet corn rapidly change during storage at temperatures above 0 deg. and, if kept for prolonged periods, the temperatures must be closely watched. In fruits, chemical and physical changes take place rapidly and, even at 0 deg. F., strawberries rapidly lose their flavor because of the evaporation of the volatile oil and other chemical and physical changes which alter their appearance and flavor.

If low temperatures are as important as these investigations seem to indicate, then the quick-frozen process in satisfactory preservation for foods over long periods of time will mean complete revolution in storage warehouse practice.

Power Plant Engineering Developments and News

Straightline Sewage Screen

RECENTLY-ANNOUNCED Straightline Screen consists of a rack made up of steel bars, usually set vertical or at an angle of about 60 deg. with the horizontal. The clear openings between bars may be from ½ in. to 6 in., depending on requirements; the screens are made of any width from 3 ft. up to 15 ft., or more if desired, by the Link-Belt Co., 910 S. Michigan Ave., Chicago, Ill.

The rack is cleaned by a rake, secured to a carriage, which travels back and forth over the screen bars. On the upward travel, the rake engages with the rack and carries the accumulated solids up to the top of the screen. As the rake passes the top of the screen, a scraper cleans off the adhering solids into a trough or conveyor. It is then carried back, clear of the rack, to the bottom of the screen, where it is again lowered into engagement with the bars, for a repetition of the operation.

The speed of the rake is approximately 7 ft. per min. By means of a time relay, the rake is stopped at the highest and lowest position for half a minute. This time may be varied up to 30 min. to suit local conditions.

One set of machinery can drive several units. If two units are used, the carriages are counterbalanced, one going up, while the other one comes down.

STRAIGHTLINE SCREEN, SHOWING CLEANING RAKE MECHANISM

Shadow Wall Burner, Air-Cooled Wall and Coal Distributor

KENNEDY VERTICAL Shadow Wall Burner, shown in Fig. 1, is designed for installation in water-cooled furnaces, to permit the use of straight tubes in the water wall. The principle of this burner is similar to that of the vortex burner, designed for horizontal firing. The stream of primary air and coal is delivered from the burner orifice against the V-shaped deflector, which is welded to, and forms a part of, the water-wall tube installed immediately in front of the burner orifice. Thus the stream of primary air and coal is divided into two parts. The secondary air is delivered between the adjacent tubes and is regulated by deflectors, designed to adjust the direction of the secondary air stream against the primary air and coal stream. This design is to give high turbulence and efficient combustion with the least amount of excess air.

Figure 1 also shows a section of the Kennedy shadow wall, which consists of bare water tubes arranged vertically in front of the refractory wall. The tubes are set out into the furnace some distance from the face of the refractory wall, spaced so that the refractory wall is under the cooling effect of the water tubes. That portion of the tube facing the flame is, of course, exposed to direct radiant heat. The portion of the tube adjacent to the refractory wall receives radiant heat reflected from the hot surface of the refractories. Thus, all of the water tube surface is exposed to radiant heat. This

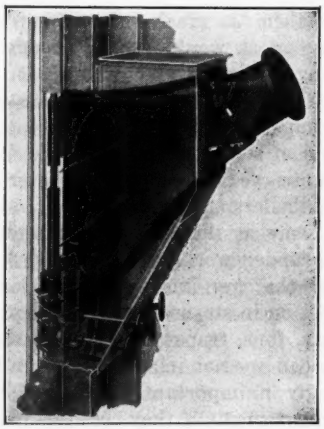


FIG. 1. VERTICAL SHADOW WALL BURNER FOR WATER-COOLED FURNACES.

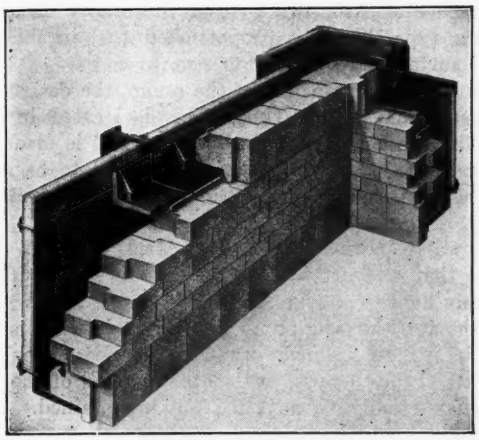


Fig. 2. AIR-COOLED WALL OF UNIT SUPPORTED TYPE.

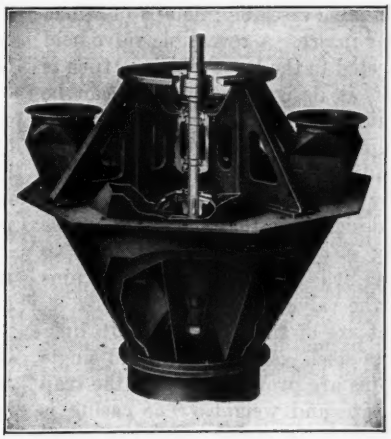
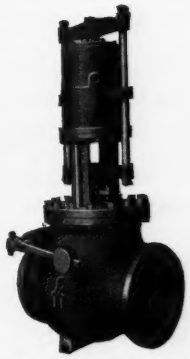


FIG. 3. PULVERIZED COAL DISTRIBUTOR



CYLINDER OPERATED BLEEDER LINE VALVE OF THE SCHUTTE & KOERTING CO.

wall is built to afford high furnace efficiency over a wide range of ratings, with low first cost and low maintenance. Kennedy Air-Cooled Wall of the unit supported type is shown in Fig. 2. Vertical members carry cast-iron brackets arranged horizontally, which in turn carry the unit blocks. A device is provided to hold the block in place on the bracket and at the same time to allow for the necessary movement brought about by expansion. The horizontal joints are of the ship-lap type to permit lateral movement, due to expansion, and so on, without leakage. Special corner blocks are used which are provided with sliding, or ship-lap, joints for accommodating the adjacent side wall blocks.

Air circulation is provided for in the spaces between the back of the refractory wall and the cover plates, the air flow being in a horizontal direction. The space at the back of each horizontal section is, in effect, a complete duct or passage. These several horizontal passages terminate in vertical plenum boxes at the ends of the walls. Dampers are provided for adjusting the air flow through any section so that the cooling effect can be increased or decreased in any part of the furnace.

Pulverized coal distributor for use where one pulverizer is furnishing coal to a number of burners is shown in Fig. 3. The distributor, of the rotary type, consists of a rotating cone having vanes on the conical surface. The cone rotates in a suitable casing and is driven by an electric motor or turbine. The pulverized coal and primary air are delivered to the connection at the small end of the cone. The casing at the base of the cone is formed with suitable connection to which are attached the pipes leading to the burners. This distributor is designed not only to proportion equally the quantity of air and pulverized coal passing through it, but also uniformly to distribute the fines so that sample of coal taken from any of the outlets show the same degree of fineness. These three products are new equipment developed during the past few months by The Kennedy-Van Saun Mfg. & Engrg. Corp. of New York City.

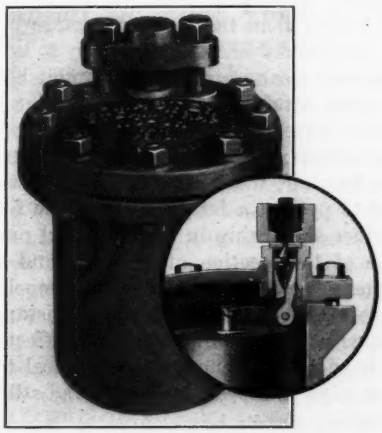
Bleeder Line Protecting Valves

DESIGNED for use in extraction lines leading from bleeder turbines to provide protection against back flow of feedwater, condensate or low pressure steam, the valve shown in the illustration is a cylinder operated bleeder line valve of the swing check type, developed by the Schutte & Koerting Co., Philadelphia, Pa. Sizes 2 to 12 in. have a single supporting link for the flapper disc, while sizes 14 to 24 in. have a double supporting link arrangement which moves the disc in a line parallel with the axis of the valve.

Adjustable counter-weight and lever are used to balance the disc and reduce pressure loss. The disc is free to swing shut when there is a back flow of water or steam and in addition, a positive closing feature is provided by the oil cylinder mounted above the valve. Oil is piped to the cylinder from main lubricating system on turbine and a spring in this cylinder forces the piston down, closing the valve when oil pressure on lower side of piston is released. The crossbar and side rod method of connecting piston to valve spindle eliminates stuffing-box in bottom of cylinder and does away with sticking of the spindle or annoying and dangerous dripping of oil on hot valve cover.

Inverted Bucket Steam Trap

INVERTED BUCKET steam trap, known as the K-Master, shown in the illustration, has recently been placed on the market. The principal feature of this



INSERT SHOWS VALVE ASSEMBLY OF K-MASTER INVERTED BUCKET TRAP

trap is stated to be the valve assembly, details of which are shown in the circular insert. A reversible valve held between two jaws connected to the lever which in turn is actuated by the bucket, is designed so that it can be changed or reversed quickly by removing the nuts, lifting off the outlet cap, lifting off the valve body, removing the valve seat, spreading the jaws and lifting out the valve. It is replaced by reversing these operations. As noted, the assembly is designed so that the valve can be reached without taking off the top of the trap. No special tools are required, it is stated, as no gaskets, pins or threads are used in the valve assembly.

Valve and valve seat are of stainless steel with linkage of monel or stainless steel. A large float and single lever with only three pins are provided to give the trap large capacity for its size and weight. The casing is subjected only to water, it is stated, and has small radiating surface. This trap is a recent product of Kaye & MacDonald, Inc., of West Orange, N. J.

Hydroseal Pump

HYDROSEAL PUMP, designed to overcome high maintenance, low average efficiency and discharge pressure limitations, for handling ash laden water, has recently been placed on the market. In the pumping of material, the operation of the hydroseal unit is identical with that of the standard centrifugal pump. Attention is called by the manufacturers, however, to the following features of the pump.

Clear water at low pressure (relative to the pump discharge pressure) is introduced to header D from which it passes into chambers E and E′ on both sides of the impeller. Due to the adhesion of this water to the side surfaces of the impeller and because of the close clearance at points F and F′, the initial pressure of the clear water is boosted above the pressure in the main volute C. This design is intended to fill the annular clearances continuously with clear water flowing into the volute, instead of with abrasive-laden water flowing in the opposite direction. The object of this is to prevent abrasives that are being pumped from wearing the outside of the impeller shrouds or the side plates G and G′. It is also intended to assure that leakage through sealing ring H is low-pressure clear water only, instead of abrasive laden water.

Clear water introduced at E and E′ need not be at a pressure higher than the pump discharge pressure, it is stated. The gland J is designed merely to hold against the low-pressure clear water to the annular bearing and to require little attention. The entire design is to prevent abrasive water from leaking out along the shaft. There is almost no "over-hang" of the impeller shaft beyond the bearing; the diagram above the cross-section is intended to present a fair analogy of the forces tending to produce shaft whip in the hydroseal pump.

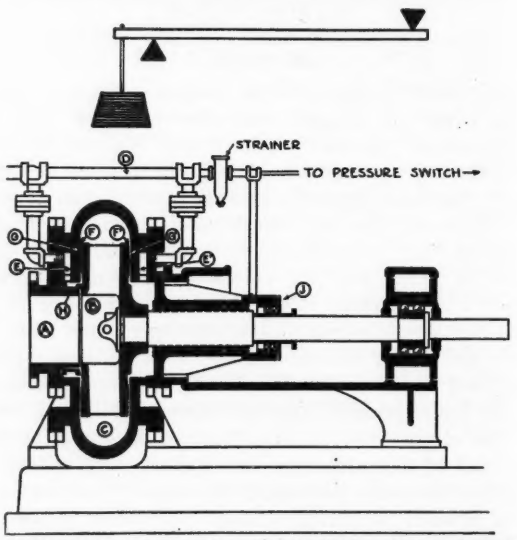
Because of the location of bearings and almost no shaft overhang, peripheral speed of the impeller can be increased to a high value. Because of this and also because leakage at the sealing ring is unaffected by the discharge head of the pump, it is practical to produce pressures as high as 150 lb. per sq. in. and still maintain high efficiencies.

The shell is of the solid-non-split type with heavy sections and proper distribution of metal in the design. The impeller of Ashcolite D is of the totally enclosed overhung type, liberally proportioned for durability; finished surfaces are ground to size.

Because of the principle of the pump, the design requires only one sealing ring. This is located in the eye in the suction side of the impeller and is made of high grade, wear resisting bronze designed to be self-adjusting and held close to the impeller by resilient packing.

The water lubricated metallic bearing is fluted spirally so that all parts of the rubbing surfaces will be effectively flushed and lubricated.

In the vertical type pump, the thrust bearing is enclosed in a close-grained, gray-iron housing, provided with set and lock screws, so that the location of the impeller may readily be adjusted and maintained.



FUNDAMENTAL PRINCIPLES AND CONSTRUCTION DETAILS OF HYDROSEAL PUMP

In the horizontal type pump, both thrust and radial bearings are rigidly supported by one heavy, gray-iron casting to insure accurate and permanent alinement. The bearing adjacent to the impeller hub has the same water circulation as in the vertical pump, except that water is admitted to the outer end and discharged into the auxiliary impeller chamber.

This new pump, made in both horizontal and vertical type as noted, is a recent product of the Allen-Sherman-Hoff Co., Philadelphia, Pa.

Spiral and Loose Metallic Packing

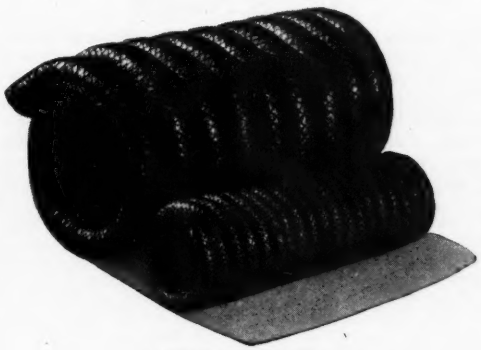
RODTITE flexible packing in loose or spiral form has recently been placed on the market by the Darcoid Co., Inc., at New York City.

Various types of this packing are recommended for general service, superheat, chemical and food products and the like. It is supplied in sizes from ¼ to 1⅛ in. in boxes from 3½ to 9 lb. It is also furnished $\frac{3}{16}$ in. diameter on spools of 1 and 2 lb. each, and the loose form is packed in 5, 10, and 25-lb. cans and 250-lb. drums.

Rodtite is manufactured of specially shredded long

fibre asbestos, anti-friction metal, graphite (except in type F) and a lubricant that is made to be unaffected by the action of heat, steam petroleum, hot or cold water.

Rodtite in spiral form is designed to be flexible and

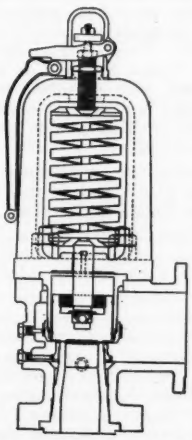


SPIRAL RODTITE

to permit easy installation in any stuffing-box. When compressed, it is free from interstices or crevices, it is claimed. It is designed to be readily removed from the stuffing-box with the ordinary packing hook.

High Capacity Safety Valves

IN THE ACCOMPANYING illustration is shown the design of new 4-in. safety valves for high capacity, recently developed for the eight new boilers at Hudson Ave. Station of Brooklyn Edison Co. These valves have a 4-in. inlet and 6-in. discharge and a capacity at 500 lb.



CROSS-SECTION THROUGH 4-IN., 164,000-LB. PER HR. SAFETY VALVE

set pressure, A.S.M.E. rating, of 164,000 lb. of steam an hour each. They are stated to be the highest capacity valves yet installed on steam boilers. The valves are designed to give the above capacity with a blowdown of 2 per cent. They are products of Crosby Steam Gage & Valve Co. of New York.

PORTABLE CABLES, wires or extension cords for temporary electrical connections should be suitable for the purpose, should be kept in first class condition and properly suspended on adequate supports.

Death of Dr. Albert A. Michelson

DR. ALBERT A. MICHELSON, Chicago, Ill., considered to be one of the greatest scientists of modern times and known especially for his measurements of the speed of light, died at Pasadena, Calif., on May 9 at the age of 78. Since the first week in March, Dr. Michelson had been confined to his home at Pasadena. Hope for his recovery was given up on May 1 and his death was hastened by a cerebral hemmorrhage on May 7.

Dr. Michelson was born in Strelno, Poland, on December 19, 1852 and was brought to the United States in 1854 by his parents who took him to Virginia City, Nev. The family later moved to San Francisco where he attended the grade and high schools. When he was 17, Michelson obtained an appointment to the United States Naval Academy at Annapolis. Graduating at the academy, he served two years as a midshipman. He was then sent to the academy as an instructor in physics where he began the series of experiments in the determination of the velocity of light in which he was engaged during the remainder of his life. His first results were so successful that his scientific curiosity was aroused, he left the navy, spent two years abroad in study and, on his return to the United States became professor of physics at the Case School of Applied Sciences in Cleveland, remaining there six years. His next connection was with Clark University from 1889 to 1892. In 1892 he was made head of the department of physics at the University of Chicago. He resigned from this post in 1929 to devote himself entirely to his work in determining the speed of light with greatest possible accuracy. In July, 1930, he was made emeritus professor by the University of Chicago.

During the World War he returned to the Navy with the rank of lieutenant commander and invented an improved range finder that was immediately adopted. In 1929 he was awarded a gold medal by the Academy of Arts and Sciences and in 1930 received the Duddel Medal of the London Physical Society.

Aside from his ability as a scientist, Dr. Michelson showed great proficiency in other fields. He was the equal of any of his colleagues at chess, bridge and billiards and at 75 was a good tennis player. He played the violin and was a painter of considerable ability.

Dr. Samuel W. Parr Dies After Long Illness

DR. SAMUEL W. PARR, emeritus professor of applied chemistry at the University of Illinois, died on the evening of May 16 at Urbana, Ill., after an illness of several months. He was 74 years old. Dr. Parr was born in Granville, Ill., in 1857. After receiving his degree of Bachelor of Science at the University of Illinois in 1884 and the degree of Master of Science from Cornell University in 1885, he studied abroad at the University of Berlin in 1900 and at the Polytechnikum at Zurich in 1901. In 1885 he was instructor in general science and from 1886 to 1891 professor of general science at the Illinois College in Jacksonville. In 1891 he was made professor of applied chemistry at the University of Illinois and served on the university faculty from that time until 4 years ago, when he retired.

He was director of the Illinois State Water Survey

in 1904 and 1905 and consulting chemist on coal investigations for the Illinois State Geological Survey in 1905.

Dr. Parr devised the Parr calorimeter for determining the value of coal and other hydrocarbons, also a new type of calorimeter for determining the heat value of combustible gases. He developed alloys of various types, one of them called "illium" intended as a substitute for platinum.

Dr. Parr was author of Chemical Examination of Water, Fuel, Flue Gas and Lubricants and other books. He prepared many reports on the composition and analysis of Illinois coal and many bulletins issued by the University of Illinois Engineering Experiment Station, the Illinois Geological Survey and other organizations. In 1926 he was awarded the Chandler medal.

He was a fellow of the American Association for the Advancement of Science; a member of the American Chemical Society and president of it in 1928; a member of the American Institute of Chemical Engineers; American Society for Testing Materials; American Electrochemical Society and other scientific and technical organizations.

Annual Oil and Gas Power Meeting at Madison, Wis. June 23-26

UNIVERSITY OF WISCONSIN at Madison will be the annual meeting place, June 23-26, for the National Oil and Gas Power Division of the American Society of Mechanical Engineers. The sessions will be held in the new Mechanical Engineering building on the west campus, which will be dedicated on June 22 with many of the oil and gas power representatives present for the ceremonies.

The engineering faculty of the University will be hosts for the meeting. Ben C. Elliott, professor of mechanical engineering, is general chairman and R. E. Puerner, assistant professor of machine design, is treasurer. Faculty committees are in charge of arrangements.

The program lists a large number of engineers from research and manufacturing plants who will speak on the results of recent research in Diesel engine development and other phases of oil and gas power operation. An extensive exhibit of engines, parts, and accessories will be on view. A motor trip to the Fairbanks-Morse plant at Beloit will be made for an afternoon plant inspection.

Concluding the dedication program for the Mechanical Engineering faculty, industrial representatives of the state and the Engineers' Society of Milwaukee will hold a joint banquet meeting at the Memorial Union at which a speaker of national importance will be heard. The general subject will be Industrial Research.

The closing event, on the afternoon of June 26, will be an auto trip to the Dells of Wisconsin River. For those interested, a special trip will be arranged to Milwaukee industrial plants and to the Grand Haven Diesel power plant.

For women guests, committees have mapped an extensive recreation program, including a reception and tea, boat trips, card parties, and dancing. Another feature for women will be a trip to, and picnic lunch at, the civil engineering camp of the University of Wisconsin at Devils Lake.

Delegates will be housed at Adams and Tripp halls on the west campus.

News Notes

R. H. BAKER CO., INC., announces the removal of its New York office to the Chrysler Bldg, New York City.

CEMENT GUN CO. INC., Allentown, Pa. announces that since April 28 its New York office has been located at Room 2513, Empire State Bldg., New York City.

AT THE ANNUAL meeting of Cutler-Hammer, Inc., Milwaukee, Wis. held April 14, Frank R. Bacon, former chairman of the board, was elected president to fill the vacancy caused by the death of Beverly L. Worden. The office of chairman of the board was abolished. At the same meeting, other officers and directors were elected as follows: vice presidents—F. L. Pierce, J. C. Wilson; treasurer, H. F. Vogt; secretary, W. C. Stevens. Directors elected were F. R. Bacon, F. L. Pierce, J. C. Wilson, H. F. Vogt, W. C. Stevens, T. Johnson Ward, of Cassatt & Co., Philadelphia, Carl A. Johnson, president of the Gisholt Machine Co., Madison, Wis., L. A. Lecher, of Bottum, Hudnall, Lecher, McNamara & Michael, Milwaukee, Wis., G. S. Crane, general sales manager of Cutler-Hammer, Inc., E. A. Bacon, vice-president of the First Wisconsin National Bank. The new officers and board assume office at once.

M. B. MACNEILLE has resigned from Fairbanks, Morse & Co. and joined the sales organization of the Dayton-Dowd Co., Quincy, Ill. He will act as western sales manager with headquarters in San Francisco. Mr. MacNeille was for 19 yr. connected with the Pump Division of Fairbanks, Morse & Co., in the capacities of designing engineer on centrifugal pumps, chief engineer of the hydraulic division and for the past six years, manager of the pump division.

R. F. PACK was elected president of Northern States Power Co. at a recent meeting of the board of directors, it has been announced by John J. O'Brien, president, Standard Gas and Electric Co. Charles F. Stuart was appointed assistant to the president. Mr. Pack has been vice president and general manager of Northern States Power Co. since 1916. The office of president has been held by Mr. O'Brien, who, as president of Byllesby Engineering and Management Corp. and Standard Gas and Electric Co. has also served as president of most of the subsidiary and affiliated companies comprising the Standard Gas and Electric Co. system. The board of directors also elected as officers of Northern States Power Co. and members of the board, J. J. Molyneaux, vice president and treasurer; Henry Grenacher, vice president in charge of operation; T. D. Crocker, vice president and H. E. Young, vice president in charge of sales.

THE ASHMEAD-DANKS CO., mechanical and sales engineers announce their change of address from 7016 Euclid Avenue to Room 515, Rockefeller Building, Cleveland, Ohio.

GEO. A. ORROK, DAVID MOFFAT MYERS AND W. A. SHOUDY, consulting engineers, announce the removal of their offices to 21 East Fortieth St., New York City, on May 1, 1931.

ON MAY 1 the manufacturing business of the Lambert Hoisting Engine Co. of Newark, N. J., was acquired by the McKiernan-Terry Corp. including all of the Lambert designs, patents, machinery, patterns, fixtures, inventory and all essential materials for the continued production of the Lambert line. To preserve the identity of the Lambert name, it will hereafter be known as the Lambert Hoisting Engine Division of the McKiernan-Terry Corp., in charge of and under the personal supervision of John A. Lambert. The sales activities will be transferred to the general sales office of the McKiernan-Terry Corp., 15 Park Row, New York.

C. H. ADAMSON, who has been secretary and director of advertising and sales promotion for the Stephens-Adamson Mfg. Co., Aurora, Ill., has been made district manager of the new Chicago office of the company, which opened on May 1 at Room 812, 20 N. Wacker Drive, Chicago, Ill.

G. S. HERINGTON, for the past nine years in charge of sales engineering and erection of pulverized coal plants for Heyl & Patterson, Inc., Pittsburgh, Pa., has opened an office at 1440 Broadway, New York City, where he will specialize in pulverized coal and pneumatic and mechanical handling equipment.

THE BLAW-KNOX CO., Pittsburgh, Pa., has acquired the exclusive sales and manufacturing rights of the ATECO line of earth moving machinery from the American Tractor and Equipment Co. of Oakland, Cal., for the United States east of the Rocky Mountains and for all other countries.

FAIRBANKS, MORSE & Co. has announced the appointment of R. H. Bacon, former advertising manager for the company, as manager of the Pump Sales Division with headquarters in Chicago. Mr. Bacon has been associated with the company since 1925 when he took charge of publicity for the Diesel Engine Division. Shortly thereafter he was placed in charge of general publicity and since 1929 has been manager of the Advertising and Publicity Dept.

From 1922 to 1925 he was associate editor of Power Plant Engineering. Prior to that time he was assistant engineering editor of Electrical World and for three years had been assistant electrical engineer for the Copper Range Mining Co. He is a graduate electrical engineer, University of Illinois, '16.

THE BRISTOL Co., Waterbury, Conn. announces that on May 1 its Pittsburgh office was moved to Koppers Bldg., 436 Seventh Ave., Pittsburgh, Pa.

BECAUSE ECONOMY in the purchase, handling and use of railway fuel is more than ever important at present, the executive committee of the International Railway Fuel Assn. has decided to hold a convention at Hotel Sherman, Chicago, in place of the annual meeting usually held in May. In consideration of present reduced business, the convention will be limited to two days, Sept. 15 and 16, for consideration of only matters bearing on fuel performance and operating efficiency, without exhibit or entertainment features.

W. C. HALL, chief engineer of Swift & Co., at Harvey, La., has recently been promoted to the position of superintendent and chief engineer for the company at Havana, Cuba. Here a new plant is being rapidly completed representing an expenditure of about $2,500,000. This will be the largest plant in Cuba owned and operated by Swift & Co. Mr. Hall's promotion will take effect June 1. He is a graduate of the Mechanic Arts High School of Boston and later attended Armour Institute of Technology in Chicago, Ill. He began his engineering work in Boston as operating engineer for the Quincy Market and Cold Storage Warehouse Co., later becoming chief engineer and superintendent of this organization. Later he was chief engineer for Swift & Co. at its Chicago plant and was then transferred to the plant at Harvey, La. as chief consulting engineer.

Books and Catalogs

STECOM AUTOMATIC FEED WATER UNITS, built for steam pressures up to 125 lb. for boilers from 5 to 215 hp. and designed to return condensate, add makeup water, maintain boiler level and keep steam lines free of condensate, entirely automatic in operation, are described in a new bulletin by Steam and Combustion Co., 205 West Wacker Drive, Chicago, Ill.

JONES WORM GEAR SPEED REDUCERS, Series OH for small electric motor drives, in sizes up to 7 hp., ratios from 5 to 1 up to 50 to 1 are described in Bulletin 49, just issued by W. A. Jones Foundry & Machine Co., 4401 Roosevelt Road, Chicago, Ill.

VERTICAL FOUR-CYCLE DIRECT INJECTION Type B Diesel Engines are described in a bulletin just issued by Worthington Pump & Machy. Corp., 2 Park Ave., New York. These are built in 2, 3, 4, 5 and 6-cylinder combinations with a continuous duty rating of 25 hp. per cylinder at 514 r.p.m., giving a range of sizes from 50 to 150 hp. The company has also issued a new bulletin describing vertical triplex single-acting power pumps, forged liquid end pattern, in capacities from 1 to 75 g.p.m. Horizontal duplex piston pattern hot oil pumps in capacities from 77 to 153 g.p.m. are described in another new bulletin. These are for hot feed or hot flash service at temperatures up to 700 deg. F. A fourth new bulletin discusses in detail horizontal duplex piston pumps, Type S.P., for maximum working pressure at steam end of 150 lb. and at liquid end, Wompco 450 lb., cast steel 600 lb. capacities are from 119 to 233 g.p.m.

WRIGHT ELECTRIC HOISTS in capacities from 1000 to 10,000 lb. are described in a new 8-page illustrated bulletin by Wright Mfg. Co., Bridgeport, Conn.

COMBUSTION ENGINEERING CORP., 200 Madison Ave., New York, is issuing a folder including photographs and application drawing, a table of dimensions and capacities of the C-E Stoker Unit, which has been developed for the firing of small boilers up to 150 hp. Three sizes are available with coal burning capacities of 300, 600 and 1000 lb. of coal per hour respectively.

VICTOR DAMPER REGULATORS No. 501 for low-pressure and vapor heating boilers, No. 502 for medium pressure power boilers, and No. 503 for high-pressure power plants are described and illustrated in a new 12-page bulletin by the Atlas Valve Co., 282 South St., Newark, N. J. The regulator is described in detail and many installation drawings show its various applications. Complete list of parts and price list are also included.

CROCKER-WHEELER SPEED CHANGER is a device for use with any standard Crocker-Wheeler motor to reduce or increase the speed of the driving shaft and is described and illustrated in a recent bulletin issued by Crocker-Wheeler Electric Mfg. Co., Ampere, N. J. This speed changer is designed to operate by the adhesion of hardened and ground steel surfaces rolling upon each other and held together with sufficient pressures to insure driving without slip.

BECO-TURNER baffle wall is described in a new 8-page bulletin by the Boiler Engineering Co., 24 Commerce St., Newark, N. J. This contains engineering information on boiler baffle walls with details of actual walls applied to all types of horizontal and vertical water-tube boilers.

DIFFERENTIAL PRESSURE CONTROL is the subject of a new 16-page well illustrated bulletin issued by the Northern Equipment Co., Erie, Pa., describing the methods of obtaining this control with Copes feedwater regulators. The bulletin discusses: why control the differential pressure, how it is most effectively controlled and does it pay to control it. In addition to complete details of the Copes valves developed for this purpose, the bulletin contains many interesting charts of feedwater flow under various conditions and diagrams of the way in which the new Copes differential valve and feedwater regulator are applied to different types of boilers.

CARBON BRUSH MANUAL, recently issued, is designed to simplify greatly the selection and specification of carbon and metal-graphite brushes. The new shunt nomenclature of the National Electrical Manufacturers Association has been adopted. Essential details for a complete brush specification are listed and discussed in the sequence which has been found most convenient. Tables of physical characteristics have been omitted. Instead, a cross index of grades and their applications simplifies the selection of a suitable grade for any service. Examples illustrate the manner in which the composite specification for a brush is derived and the price computed. The manual is a recent publication of National Carbon Co., Inc., Cleveland, Ohio.

POWER PLANT EQUIPMENT is the title of an attractive 24-page bulletin recently published by Elliott Co., Pittsburgh, Pa. with works and sales headquarters at Jeannette and Ridgway, Pa. This bulletin covers the entire Elliott line of power equipment, devoting one page to a product and including the tube cleaners manufactured by its associates the Liberty Manufacturing Co. and Lagonda Manufacturing Co. Products briefly shown and described in the bulletin include: turbine and engine-generator units, motors and motor-generators, centrifugal blowers, condensers, ejectors, deaerators, feed water heaters, desuperheaters, strainers and power accessories.

NUGENT pressure-vacuum oil fillers for fuel, lubricating and other oils are described in detail and their applications shown in Bulletin No. 7A just issued by Wm. W. Nugent & Co., 410 N. Hermitage Ave., Chicago, Ill.

TYCOS INSTRUMENTS for use in steam power plants are described in detail in a new general catalog of 84 pages by Taylor Instrument Cos., Rochester, N. Y. Diagram of a power plant shows application of all types of instruments; then follow descriptions of thermometers, mercury columns, barometers, draft gages, hygrometers, hydrometers, oil testing equipment CO recording pressure gages and thermometers and pyrometers, selective switching devices and temperature regulators.

ROCKWOOD Short-Center Flat Belt Drive, in which the weight of the motor is applied to maintain automatically uniform belt tension is described and illustrated in a new 40-page bulletin by The Rockwood Mfg. Co., Indianapolis, Ind.

MECHANICAL-DRIVE TURBINES, their construction and application to the operation of centrifugal pumps, paper machines, compressors, fans and similar equipment are described in bulletin GEA-1145A, recently issued by General Electric Co., Schenectady, N. Y. Installations of these turbines are shown for operation at pressures as high as 600 lb. per sq. in. and steam temperatures up to 750 deg. F. The turbines are usually of the multi-stage type and details of the rotor construction, governor mechanism and other parts are clearly shown.

LUKENWELD Construction, which is stated to be the fabricated product obtained by welding Luken welding quality rolled steel according to insurance welding practice, is discussed in a recent 20-page bulletin by Lukenweld, Inc., Coatesville, Pa.

TWO RECENT BULLETINS, No. L-20426 and L-20447, covering both motor-driven and turbine-driven condensate pumps respectively and containing characteristic curves showing the effect of submergence on the capacity of pumps have recently been issued by Westinghouse Elec. & Mfg. Co., So. Philadelphia, Pa. The company has also issued a 12-page bulletin on Westinghouse 3600-r.p.m. steam turbine-generator units. This shows in detail the construction of rotor, governor mechanism and other parts, also the construction of the generator and its ventilating system and the exciter, and shows illustrations of typical installations.

Power Plant Construction News

Calif., Arbuckle—The Union Ice Co., 354 Pine Street, San Francisco, Calif., has plans under way for a precooling plant at Arbuckle to cost close to $25,000 with equipment. Company engineering department is in charge.

Calif., Brawley—The Board of City Trustees is planning extensions and improvements in municipal electric light and power plant, to cost about $150,000. A special election is being arranged to vote bonds in amount noted.

Calif., Vernon—The Bethlehem Steel Corporation, South Bethlehem, Pa., plans installation of electric power equipment in connection with a proposed expansion and improvement program at plant of its subsidiary, the Pacific Coast Steel Co., Vernon, entire project reported to cost in excess of $1,000,000.

D. C., Washington—The Bureau of Yards and Docks, Navy Department, Washington, will receive bids until June 10, for installing boilers, stokers and foundations at the local navy yard, as per Specification 6389.

Fla., Ocala—The City Council, J. R. Martin, Mayor, is asking bids until July 7, for equipment for municipal electric light and power plant, as per specifications on file.

Ga., Albany—The Georgia Power Co., Atlanta, is reported planning the construction of a new transmission line from Albany to Americus, to operate at 44,000 volts, including power substation facilities. Company engineering department is in charge.

Ind., Lafayette—The Board of Trustees, Purdue University, has awarded a general contract to A. E. Kemmer, Lafayette, for an addition to steam power plant on the campus, estimated to cost about $100,000 with equipment. Walter Scholer, Wallace Building, is architect.

Iowa, Cedar Rapids—The Iowa Railway & Light Co., Cedar Rapids, will soon begin work on an addition to local steam-operated electric power plant, with installation of additional equipment, reported to cost over $80,000. Company engineering department is in charge.

Kan., Colby—The Symns-Shafer Mercantile Co., Colby, has plans for a one and two-story cold storage and refrigerating plant, 60 x 240 ft., to cost about $55,000, with equipment. Benjamin H. Byrnes, National Bank of America Building, Salina, Kan., is architect.

Miss., Holly Springs—The Common Council is said to be planning the installation of an oil-burning engine and auxiliary power equipment in the municipal power station.

Nev., Boulder City—United States Bureau of Reclamation, Denver, Colo., is said to be planning early call for bids for the installation of an electric distributing system at Boulder City, in connection with the Hoover Dam project, at that place, including poles, copper wire, transformers and other equipment.

N. Y., Gouverneur—The Board of Village Trustees is said to be planning the installation of electric pumping machinery and auxiliary equipment, in connection with an expansion and improvement program at municipal waterworks, to cost $120,000. A bond issue in amount noted is being arranged.

N. Y., Rochester—Water Department, City Hall, Rochester, plans installation of electric-operated pumping machinery and auxiliary power equipment in new waterworks station at Rondout Creek, entire project to cost $1,125,000. An appropriation in amount noted has been arranged.

N. D., Mohall—At a special election, plans have been approved for a municipal electric light and power plant, and work will be placed under way by Common Council at an early date. Estimates of cost are being made.

Ohio, Akron—The Sun Oil Company, 1608 Walnut Street, Philadelphia, Pa., plans installation of pumping machinery and other power equipment in proposed new oil storage and distributing plant on Home Avenue, North Akron, entire project to cost in excess of $100,000.

Ohio, Cincinnati—The Board of City Commissioners has tentative plans under consideration for extensions and improvements in municipal waterworks, and new power plant unit, entire project to cost over $2,000,000. The Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., is consulting engineer.

Ohio, Newton Falls—The Newton Steel Co., Youngstown, Ohio, is said to be planning the installation of electric power equipment in connection with a proposed expansion and improvement program at steel mill at Newton Falls, entire propect reported to cost more than $750,000.

Okla., Enid—The Enid Terminal Elevator Co., 801 Kenwood Boulevard, Enid, plans installation of electric power equipment, conveying and elevating machinery in connection with addition to grain elevator, entire project to cost over $175,000.

Ore., Medford—The California-Oregon Power Co., Medford, has plans for the completion of its Prospect hydroelectric power project on the Rogue River, in the southern part of the State, and will proceed with development at an early date It is reported to cost over $1,500,000 with transmission system. The company is an interest of the Byllesby Engineering & Management Corporation, 231 South LaSalle Street, Chicago, Ill.

Pa., Jeddo—The Jeddo Highland Coal Co. has completed plans for a new power plant at its local coal mining properties, reported to cost over $60,000, with equipment. The Ballinger Co., Twelfth and Chestnut Streets, Philadelphia, Pa., is architect and engineer.

Pa., St. Nicholas—The Philadelphia & Reading Coal & Iron Co., Reading Terminal Building, Philadelphia, Pa., is completing plans for a new electric-operated coal breaker in the vicinity of St. Nicholas, to be equipped for an output of 12,500 tons per day, reported to cost close to $1,000,000, with machinery. Company engineering department is in charge.

S. D., Vermillion—The Common Council has plans nearing completion for a proposed municipal electric light and power plant to cost about $85,000, of which equipment will represent close to $70,000. Charles A. Trimmer, Madison, S. D., is consulting engineer.

Texas, Farmersville—The Common Council is said to be planning the construction of a municipal ice-manufacturing plant. Estimates of cost will soon be made.

Texas, Viola—The Houston Oil Co., Houston, Texas, plans installation of electric power equipment in connection with a proposed expansion and improvement program at oil refining plant at Viola, near Corpus Christi, entire project reported to cost close to $1,000,000.

Texas, Woodsboro—The Central Power & Light Co., San Antonio, Texas., is considering the construction of a transmission line in the vicinity of Woodsboro, including an electric power substation for switching and distributing service.

Va., Fredericksburg—The Sylvania Industrial Corporation, 122 East Forty-second Street, New York, plans installation of electric power equipment in a proposed addition to transparent wrapping material mill, estimated to cost over $500,000, with machinery.

Wash., Aberdeen—The City Council is considering a report made by Morse & Pollock, Smith Tower Building, Seattle, Wash., consulting engineers, for extensions and improvements in the municipal water system, including pumping machinery, filtration equipment and other power equipment, entire project to cost over $350,000.

W. Va., Morgantown—A. W. Hawley, Morgantown, and associates are organizing a new company to construct and operate a mechanical coal-washing plant to cost over $100,000, with equipment. A site is being selected in Preston County.

Wis., Eau Claire—The Dunphy Boat Mfg. Co., Eau Claire, is said to be planning the installation of electric power equipment in connection with proposed rebuilding of portion of plant, recently destroyed by fire with loss of about $70,000.

Wis., Oshkosh—The Paine Lumber Co., Oshkosh, plans installation of electric motors and other power equipment in connection with proposed rebuilding of portion of sash and door factory, recently destroyed by fire with loss of about $60,000.

Wis., West De Pere—The De Pere Paper Mfg. Co., West De Pere, is planning installation of electric power equipment in connection with proposed rebuilding of portion of mill, recently destroyed by fire with loss in excess of $100,000.